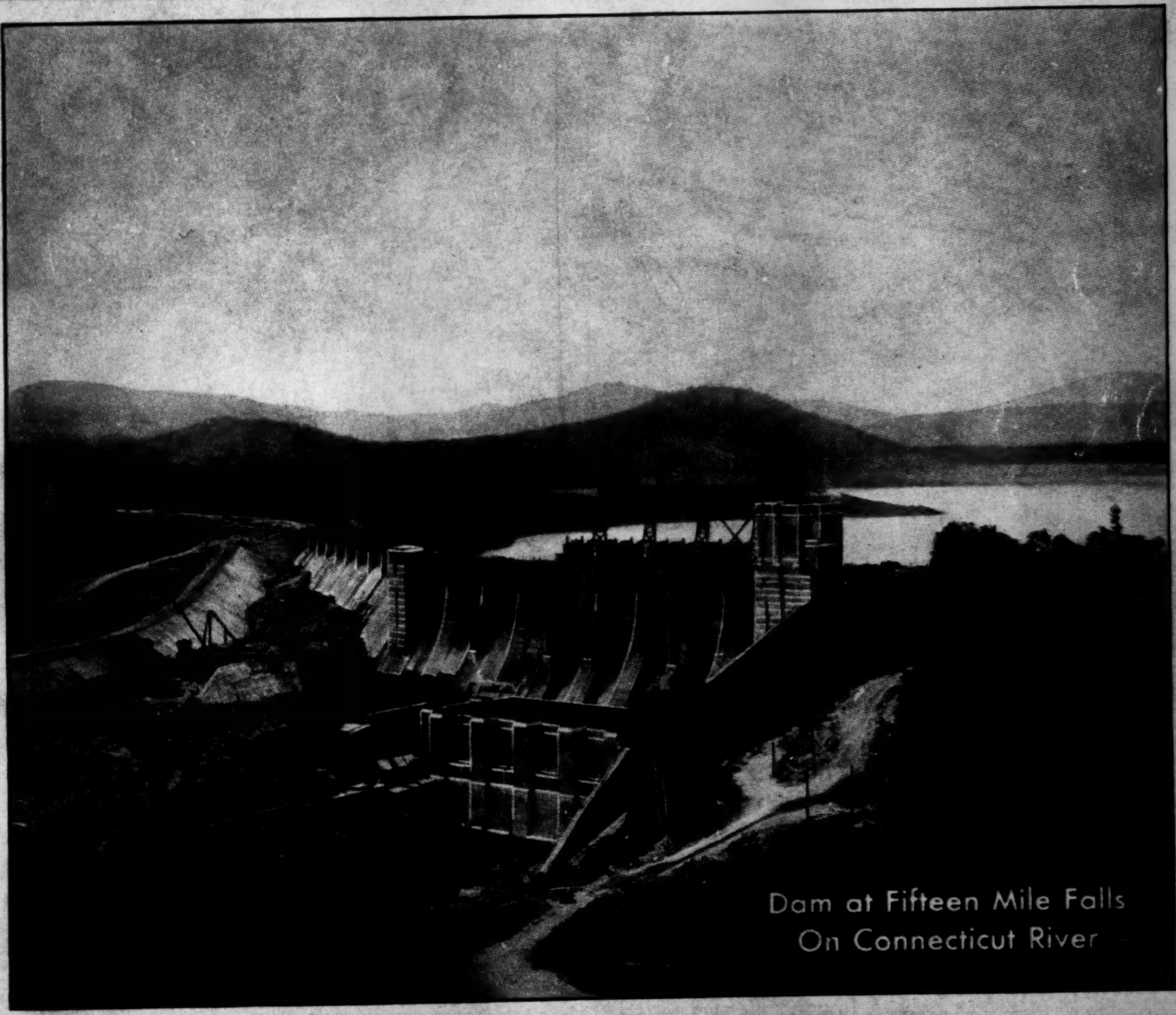
gineering
brary

JAN 29 193

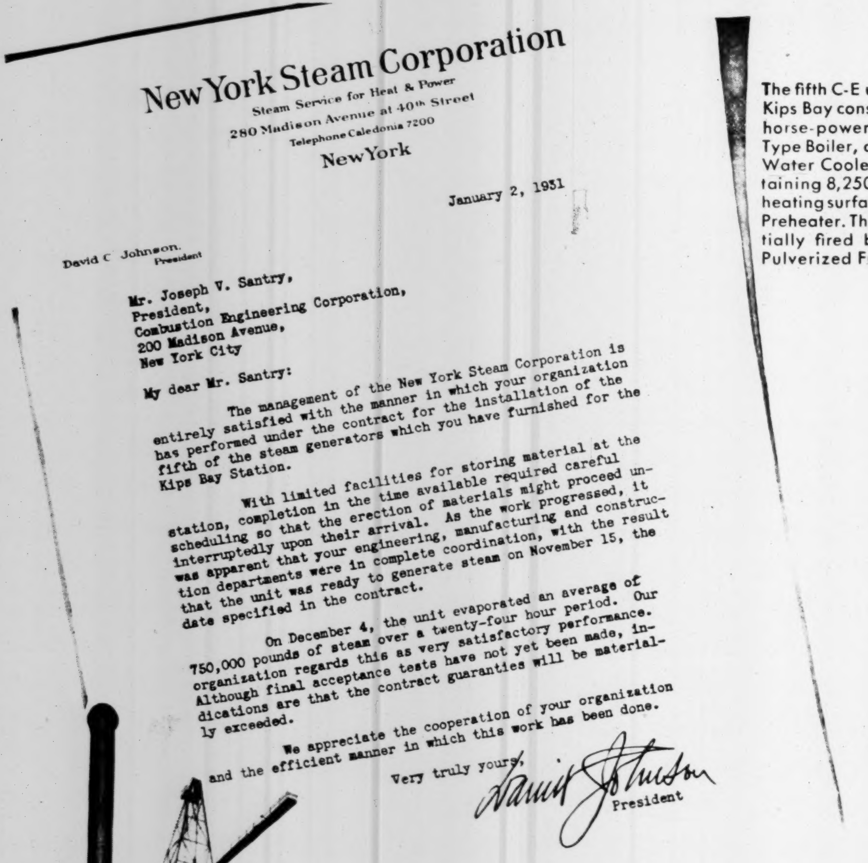
MECHANICAL ENGINEERING



Dam at Fifteen Mile Falls
On Connecticut River

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

February 1931



New York Steam Corporation
Steam Service for Heat & Power
280 Madison Avenue at 40th Street
Telephone Caledonia 7200
New York

January 2, 1931

David C Johnson,
President

Mr. Joseph V. Santry,
President,
Combustion Engineering Corporation,
200 Madison Avenue,
New York City

My dear Mr. Santry:

The management of the New York Steam Corporation is entirely satisfied with the manner in which your organization has performed under the contract for the installation of the fifth of the steam generators which you have furnished for the Kips Bay Station.

With limited facilities for storing material at the station, completion in the time available required careful scheduling so that the erection of materials might proceed uninterruptedly upon their arrival. As the work progressed, it was apparent that your engineering, manufacturing and construction departments were in complete coordination, with the result that the unit was ready to generate steam on November 15, the date specified in the contract.

On December 4, the unit evaporated an average of 750,000 pounds of steam over a twenty-four hour period. Our organization regards this as very satisfactory performance. Although final acceptance tests have not yet been made, indications are that the contract guaranties will be materially exceeded.

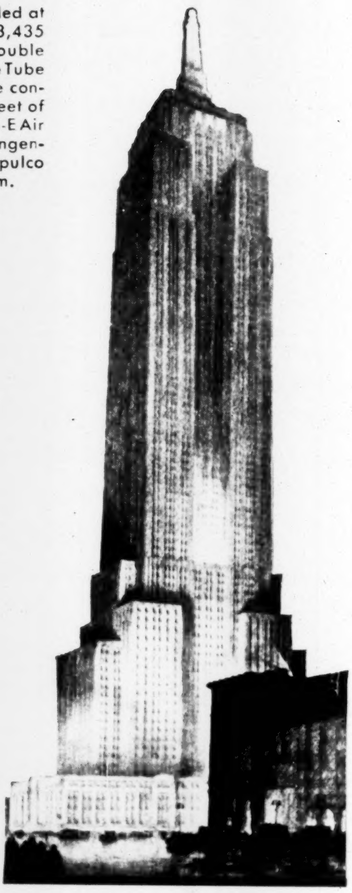
We appreciate the cooperation of your organization and the efficient manner in which this work has been done.

Very truly yours,

David Johnson
President

New York Steam Corporation
Kips Bay Station

The fifth C-E unit installed at Kips Bay consists of a 3,435 horse-power Ladd Double Type Boiler, a C-E Bare Tube Water Cooled Furnace containing 8,250 square feet of heating surface and a C-E Air Preheater. The unit is tangentially fired by the Lopulco Pulverized Fuel System.



THE EMPIRE STATE BUILDING ... the world's tallest structure ... is indicative of the trend toward central heating of large buildings. All the steam required by this greatest of skyscrapers is supplied by the Kips Bay Station.

Steam Heating

The Kips Bay Station of the New York Steam Corporation, bordering on the East River at 35th Street, was built in 1926 to take care, in part, of the heating load in the Grand Central Zone and adjacent territory.

This station, one of the first large Central Heating Plants to use pulverized fuel, is equipped throughout with Combustion Engineering Corporation's steam generating equipment.

The original installation consisted of three steam generating units, installed in 1926. A fourth unit was added in 1927 to take care of the growing demands.

To provide for this winter's increased load, including the heating of the new Empire State Building, the New York Steam Corporation, on March 13, 1930, placed a contract with the Combustion Engineering Corporation for a fifth unit similar to the four units already installed but to deliver 700,000 pounds of steam per hour, specifying that the unit should be installed by November 15, 1930.

On the scheduled date, November 15, 1930—eight months and two days after the contract was signed—the unit was generating steam. On December 4, 1930, it generated an average of 750,000 pounds of steam per hour over a 24 hour period.

COMBUSTION ENGINEERING CORPORATION

TWO HUNDRED MADISON AVENUE • • • • NEW YORK

STOKERS · BOILERS · PULVERIZED FUEL EQUIPMENT · AIR PREHEATERS · WATER COOLED FURNACES

Mechanical Engineering

The Monthly Journal Published by
The American Society of Mechanical Engineers
Publication Office, 20th and Northampton Streets, Easton, Pa. Editorial and Advertising Departments at the Headquarters of the Society, 29 West Thirty-Ninth Street, New York
(Cable Address, "Dynamic," New York)

Vol. 53 February, 1931 Number 2

CONTENTS OF THIS ISSUE

Engineering, Economics, and the Problem of Social Well-Being . . . 99
The Engineer's View . . . *R. E. Flanders* . . . 99
The Economist's View . . . *W. C. Mitchell* . . . 105
Low-Cost Peak-Load Capacity With Bleeder Turbines . . . *A. G. Christie and Warren Viessman* . . . 111
High-Pressure and High-Temperature Steam for Locomotives . *C. F. Hirshfeld* . . . 118
Spectroscopic Apparatus in Industry . . . *C. C. Nitchie* . . . 123
Thermal Properties of Compressed Liquid Water . . . *J. H. Keenan* . . . 127
Some Final Values for the Properties of Saturated and Superheated Water . . . *F. G. Keyes and L. B. Smith* . . . 132
Some Additional Volume Data for Superheated Steam . . . *L. B. Smith and F. G. Keyes* . . . 135
Report of Progress in Steam Research at Bureau of Standards . . . *N. S. Osborne* . . . 137
Progress in Oil Refining . . . 139
Instruments and Apparatus—Part 16—Density Determinations . . . 152

DEPARTMENTAL

Survey of Engineering Progress . . . 141
A Review of Attainment in Mechanical Engineering and Related Fields
Work of the Boiler Code Committee . . . 154
Correspondence . . . 155
Placing Wet Concrete With Belt Conveyors; Use of Fuel in the Manufacture of Cement; Automatic Loom and Its Effect on Unemployment
Engineering and Industrial Standardization . . . 157
A.S.A. Elects Officers; Splines and Splined Shafts; Standard Specifications for Sieves; New American Standards
Editorial . . . 158
A Sociologist Looks at Machines; "Electrical Engineering;" Interstate Power; Engineering, Economics, and Social Well-Being; The Bethlehem-Youngstown Merger Decision; The D'Ascanio Helicopter; Richard Moldenke—An Appreciation
Book Reviews and Library Notes . . . 161
Oil Conservation and Fuel-Oil Supply; Books Received in the Library
Synopses of A.S.M.E. Fuels Meeting Papers . . 163
Synopses of A.S.M.E. Transactions Papers . . . 164
Current Mechanical Engineering Literature . . . 169

ADVERTISING

"Chicago Welcomes You" Section, Including Chicago Power Show Guide . . . 77
Display Advertisements . . . 1
Classified List of Mechanical Equipment . . . 32
Professional Engineering Service Section . . . 132
Opportunity Advertisements . . . 136
Alphabetical List of Advertisers . . . 138

Price 60 Cents a Copy, $5.00 a Year; to Members and Affiliates, 50 Cents a Copy, $4.00 a Year. Postage to Canada, 75 Cents Additional, to Foreign Countries, $1.50 Additional. Changes of Address should be sent to the Society Headquarters.

Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921.

Copyrighted, 1931, by THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

What It's All About

ENGINEERING AND ECONOMICS are very definitely interrelated factors in modern society. One cannot be considered without the other, as is shown convincingly by the addresses by Mr. Ralph E. Flanders and Dr. Wesley C. Mitchell which constitute the leading contribution to this month's MECHANICAL ENGINEERING.

If any lesson for engineers is to be learned from these addresses, it is that keener appreciation of many extra-technological phases of engineering developments must be acquired by those who direct these developments. Problems affecting society at large arising out of engineering progress cannot be left entirely to others for solution. The engineering profession itself, as Mr. Flanders points out, must develop the thinking and leadership necessary to make its works truly profitable to mankind and constructive rather than confusing.

:: :: ::

PEAK-LOAD POWER may be provided for by many expedients. Professor A. G. Christie and his collaborator Warren Viessman, review some of these in a paper in this month's MECHANICAL ENGINEERING. The method here analyzed consists in deriving peak-load capacity from bleeder turbines by allowing the steam usually bled for feedwater-heating purposes to be expanded throughout the lower-pressure stages. Inasmuch as such an expedient will result in furnishing colder water to the boiler, the use of a hot-water accumulator is suggested by the authors to provide a supply of hot feedwater during peak-load operation.

In an illustrative example, it is shown how a bleeder turbine having at most economical loading a net output of 51,150 kw. but with a maximum output of 67,825 kw. may be equipped with three accumulators at a cost of $248,000, including all accessories and engineering and overhead expenses, thus providing a 2-hour peak capacity of 10,195 kw. at a cost of $24.36 per kw. It is claimed that the proposed scheme is simple and reliable in operation and is economical in fuel consumption.

:: :: ::

WHAT CAN A locomotive designer learn from central-station practice? To answer this question, the A.S.M.E. Railroad Division turned to C. F. Hirshfeld, chief of the research department of the Detroit Edison Company. Mr. Hirshfeld prepared for the Division a paper on "High-Pressure and High-Temperature Steam for Locomotives," an abridgment of which is found in this month's MECHANICAL ENGINEERING.

As Mr. Hirshfeld sees the problem, basic changes in locomotive design are apparently necessary. Factors in the problem are those resulting from the use of higher steam temperatures and pressures and the possibility of condenser operation. Admittedly these factors present difficulties to the designer if the present type of locomotive is to be retained. Mr. Hirshfeld pictures the kind of boiler he would design for a high-pressure locomotive, and discusses some of the changes that would take place in the engine. There is plenty to think about in what Mr. Hirshfeld has to say.

:: :: ::

REPORTS of work being carried on under the auspices of the A.S.M.E. Special Research Committee on Thermal Properties of Steam have been a feature of the February issue of MECHANICAL ENGINEERING for several years. This month Professors Smith and Keyes, of M.I.T., give some final values for the properties of saturated and superheated water, and some additional volume data for superheated steam.

Dr. N. S. Osborne, of the Bureau of Standards, reports a group of measurements of heat content of saturated water and steam from 0 up to 270 deg. cent., or to a pressure of about 800 lb. per sq. in.

Prof. J. H. Keenan, of Stevens Institute of Technology, shows how to compute accurately with the data now available, the work of the feed pump and the heat transferred to the feedwater. Computing the feed-pump work on the assumption of constant-volume rather than constant entropy yields a practically correct result, but computing the heat rise by assuming it to be equal to the change in total heat of the saturated liquid states gives an error of 3.5 B.t.u. per lb. at 1200 lb. pressure.

:: :: ::

SPECTROSCOPY has invaded industry. The spectroscope, familiar to students of physics and chemistry as the instrument by means of which substances are identified by their characteristic spectral lines, has been adapted for such industrial uses as the detection and determination of impurities that affect the properties of the materials containing them. Charles C. Nitchie, in this issue of MECHANICAL ENGINEERING, describes briefly the principles of spectroscopy and one type of apparatus for making spectrographic observations. Thus does another scientific instrument become a workshop tool.

MECHANICAL ENGINEERING

Volume 53 February, 1931 No. 2

Engineering, Economics, and the Problem of Social Well-Being[1]

A Statement of the Problem and a Discussion by Representatives of These Two Professions of the Steps That Must Be Taken in Its Solution

The Engineer's View—By Ralph E. Flanders[2]

MISFORTUNE makes us thoughtful. Your speaker is not so old as some of you, but he is old enough to have lived through several business depressions, and the experience has left him with a very clear recollection of the successive states of mind which the business cycle generates. At this particular period we are due to be impressed with the complete ridiculousness of our situation—ample working capital, well-equipped factories, management and men eager to work, and eager to buy with their collective earnings the products of their collective activity. And yet things do not move. It is really quite silly.

Financiers, business men, chambers of commerce, and economists gather about, discuss the irrationality of the situation, offer many and various explanations and a few—a very few—suggestions. Still the thing doesn't go. When at last it does go it seems to do so of its own will and in its own time. It is not clear that any purposeful action of individuals or groups has affected it in the least.

This spasmodic and ineffectual interest in the economic problem reflects no credit on modern man. In particular should we as engineers be dissatisfied with our inability to exercise some measure of control over the business cycle.

In the first place, the engineer, as a number of us have been pointing out in the last few years, has definitely solved all the physical aspects of the problem. No longer are we the playthings of uncontrollable natural forces. We have come into a working agreement with Nature, and she is ready to furnish an abundance of good through our ministrations without severe physical exertion on the part of any one.

In addition to this it would seem reasonable to suppose that the same investigation of and adjustment to natural laws, and the same critical analysis of the conditions of the problem which have served the engineer in the physical field, should produce results of comparable effectiveness in the social environment. Similar methods should be similarly useful.

The engineer's contribution, then, lies in his method and viewpoint, in his already accomplished material and human achievements (not forgetting the field of management), and in his firm assurance that he has made the solution physically possible. Beyond these points he cannot yet go very far. He will have to become an economist or call on the economist for help, or join any one else who has a clear view of the situation. This paper is indeed largely a call for help. But the call comes from a profession which has already won difficult and decisive engagements in the contest.

Social Problems Presented by the Business Cycle

Let us now consider the problem in some detail, beginning at that aspect with which we find ourselves engaged at the moment.

It is intolerable and inexcusable that the business cycle should maintain its present extreme range of fluctuation. That business should pursue a perfectly level course, or even one of continuous though gradual expansion, is not be to be expected. To maintain a balance in any mechanism it is necessary to apply corrective reacting forces, and the only means for applying them is the initial effect of the disturbing forces themselves. In other words, a steam engine must slow down slightly before the governor can admit the extra steam required to maintain its speed within the predetermined limits of variation. The variation can never be reduced to zero.

It is not even desirable that there should be no fluctuations in business. All of life, animate and inanimate, is tuned to the natural rhythms of which there are so many—night and day, summer and winter, ebb and flow, and all the rest. There are health and progress in the adjustments involved. Our mechanisms of adjustment are kept in commission and free of rust. Our reactions remain dynamic and vital instead of becoming static and dead.

---

[1] Addresses delivered on President's Night, Tuesday, December 2, 1930, at the Annual Meeting of The American Society of Mechanical Engineers.

[2] Manager, Jones & Lamson Machine Co., Springfield, Vt., Vice-President, A.S.M.E.

To admit all this, however, does not excuse in the least the raging fever of the summer of 1929, or the anemic torpor of the autumn of 1930. Such extremes, with all the human misery that attends them, stand as a reproach to the intelligence and good-will of our race.

As to the nature of the distress entailed, those of us who have come up through a childhood and youth of straitened circumstances are only too well informed. For those who have lacked this important element in their early education, a substitute may be found in the reading of that large and monotonous book, "Middletown," by Robert and Helen Lynd. The industrial city there described, with all its people, habits, and institutions, is certainly not the best that could have been selected if it had been desired to make out a good case for modern industrialism. But neither is it the worst. Through it there runs, like the dull misery of a chronic ulcer, the fear of sickness and of old age, both sharpened by and based upon the fear of unemployment—a calamity hovering in the neighborhood in prosperous times, and a relentless guest at the family table in times like these.

Not only must the fluctuations of employment be reduced in their violence, but the whole level of the rewards of employment must be raised. However it may be with others of the more fortunate classes, and however doubtful the thesis may appear in the case of the individual business, it still remains clear from the broad outlook that here the interests of the worker and of the productive employer are one. High production requires high consumption. The truth of this statement is as clear in our present failure to apply it as it was in our short-lived and limited success.

Leisure—Voluntary and Enforced

These are immediate, pressing problems. Their solution will make more simple the succeeding steps of social progress. For instance, one of the essential elements of a well-rounded life is leisure. It is a commonplace criticism of our social scheme that it has destroyed leisure. This may be true for the active business and professional man, but it is not true for the ordinary citizen. *He* has leisure thrown at him in large, indigestible masses.

There is first the leisure of the advancing school age, varying in different states, but tending to raise the minimum working age throughout the country. This is on the whole a good thing. Next comes the leisure of irregular employment, whether due to misfortune, the chances of business reorganization, or unsocial characteristics in the worker himself. Seasonal unemployment comes in the same class.

Most serious, most undesired, and most senseless is this contemporaneous leisure of unemployment due to business depression. "Senseless" is the only fit characterization for a condition in which there is plenty of available working capital, factories fully equipped and ready to run, men anxious to work, and at the same time anxious to spend the wages of that work in buying the products of their industry.

Finally, there is the difficult leisure of old age. That age—the age limit above which it is not easy to get a new job—is steadily dropping. Many of us in this room have already passed that limit.

Let no man say, then, that the modern industrial world has robbed the ordinary man of his leisure. He has far more than he ever had before, but much of it comes as a curse instead of a blessing, bringing bodily and mental distress instead of refreshment and recreation. To organize this leisure and transform it into useful and valuable forms is one of the elements of our task.

When this is done there is yet another great reservoir of potential leisure to be made actual: that is, the mass of unnecessary or redundant work which clogs modern society. Most of this useless labor is engaged in distribution rather than production. While competitive production has increased in efficiency, competitive distribution has gone backward. The whole world of advertising and selling is capable of drastic deflation when we really get ready to extract *all* the available leisure from our economic organization.

We might refer to other possibilities—that, for instance, of filling life with new values of goodness, truth, and beauty appropriate to our age. But we are carrying water in a sieve if we attempt in any large-scale, effective way to bring these values into the common life without correcting our material ailments. Satisfactory physical conditions are our first responsibility, and the prime essential of any lasting success.

A More Complete Science of Economics Needed

It is clear on the face of our problem that we need a more complete science of economics, or one that is more practically applicable. While this science would seem to be fundamentally of the practical sort, we do not find that it furnishes clear guidance to the really important problems of the business office and market place. Its present rôle is that of disinterested observer, post-mortem investigator, analyst of current phenomena. In rare moments of aspiration it does venture on a diffident and tentative prophecy. Seldom indeed does it offer us the information and the instruction in basic principles which would enable us to control our economic problems instead of fluttering anxiously about them.

In its own field, engineering has been notably successful in rendering the detailed, useful service which economics has so far failed to produce. Let us review the conditions which have made the one activity so practical, while the other has been negligible in useful effect.

Interrelations of Engineering, Science, and Invention

Science assumes too much in taking to itself whatever credit there may be for our industrial civilization. This complex of factories, railways, warehouses, skyscrapers, steamships, telephones, and automobiles is the product of two concurrent but originally separate forces—science and invention.

We are invited to organize human society on the basis of human well-being, and the next step is this one of controlling the economic environment.

Engineers have provided the tools and methods to make it physically possible. The growing consciousness on the part of workers, farmers, and productive business men that they have a common interest in the matter, begins to make it humanly possible. . . . .

Let then the young and clear-headed and brave-hearted join together an extended science and an improved practice, under the fostering care of the new schools, and effectively attack the problem of economic control.

It is the beginning of the greatest adventure in social history. We must see it through!—Ralph E. Flanders.

As human affairs go, we have prospered in this country. Getting us to change our habits for something better will involve re-education as well as invention. And re-education is a slow process.

Slow; but not hopeless. The very drift of affairs is coercing us to change.... If engineers will join with the other professions who are working on the problem, we shall get on faster. For the present, workers need a clearer vision of what is possible in production, and a more constructive attitude of mind. Those needs engineers can supply.—Dr. Wesley C. Mitchell.

The progress of science is a historical commonplace. From its effective beginnings in the age of Galileo, up through the times of Newton and the early chemists to Faraday, Maxwell, Thomson, Helmholtz, Roentgen, and Curie, there is an unbroken stream of discovery, broadening and deepening as it flows. The necessary development of mathematics paralleled that of science, being often advanced by the same hands. The scene is brilliant, and it has often been painted with skill and enthusiasm.

The progress of invention has had no such brilliant presentation. From its obscure beginnings in the general use of printing, gunpowder, and the mariners' compass, it too has broadened and deepened in its ceaseless progress. But its protagonists have been humble folk, intent on immediate, practical ends; nor were these ends usually soul-stirring or important in themselves. Small chance here for colorful description or thrilling narrative.

Yet the humble, grubby inventor, without the help of science, developed and put into action a series of machines (particularly textile machinery and prime movers) which inaugurated the industrial revolution, carried it through to a technically successful conclusion (with all of its involved subsidiary problems), and changed the whole course of history. James Watt alone may be considered as having approached his problem from the scientific standpoint. It is certain that Arkwright, Crompton, and Cartwright owed little to the discoveries of Newton, and it is doubtful if the much later George Stephenson concerned himself with the chemistry of combustion, or even made calculations involving factors as simple as the force required for accelerating a given load.

But if science for many generations, while tremendously affecting man's intellectual life, had small effect on his practical actions, the progress of unaided invention in its turn fell far short of the possibilities which we are realizing today. It was not until science and invention joined forces (as they began to do in the second quarter of the nineteenth century) that the modern world of the twentieth century became possible. The refinements of power-plant and locomotive design, the effectiveness and efficiency of the automobile, the delicacy and intricacy of the radio circuit and its component units, the marvels of chemical technology, the mathematical grace of the suspension bridge with its record-breaking span, the myriad-sided problem solved in a metropolitan water supply—these achievements are not due to science alone or to invention alone, but to a union of the two. The ceremony of that union was performed in the technical school, and the vigorous and effective child of that union is modern engineering.

The engineer is both scientist and inventor, but neither exclusively. If, on the one hand, he busies himself with the experimental derivation of data for use in the formation of more accurate and extended steam tables—a project worthy of Regnault or of Joule, in which our Society has recently been engaged—he also concerns himself with ingenious alteration and refinement of the details of his mechanisms; and from time to time makes revolutionary changes in their fundamental construction—all in direct line of descent from the old inventors. The engineer likewise has brought to him the latest developments of science and mathematics in their most abstruse fields, and is finding a surprisingly large field of usefulness for what might at first appear to be impracticable discoveries in the field of "pure" investigation.

Questions Pressing for Answer

Considerable space has been given to describing this misunderstood relationship between science, invention, and engineering; but there are practical reasons for so doing.

It is my conviction that economics and business bear the same relationship to each other that science and invention did a century ago. It also seems clear that the newly organized schools of commerce and finance in our colleges and universities are strategically placed to solemnize the union of the two, but that the birth of the hoped-for offspring (shall we name the child "Social Engineering?") is long past due.

To put the matter more directly, there are a lot of rude, bald, practical questions for which we need answers. These questions are in the fields of economics, business, and finance; but there is no one in these fields to give authoritative answers to them. The following are examples of the kind of questions referred to.

> Is there any danger that the profits of general business may go too largely into capital expenditure? Is this why consuming power fails periodically to keep pace with increase of production? Another way to state the same problem is to ask if general business may be jeopardized by profits that are too large in proportion to wages.
>
> Should wild speculation be allowed to run its course? Or should it be checked, and how?
>
> Is there any unsettling, anti-social effect from tying up wealth in speculation, as compared with the directly useful activities of extraction, manufacture, and distribution?
>
> Is there any difference, so far as the stability of business is concerned, between paying out profits directly to employees and paying them out indirectly through people of wealth to servants, tradesmen, gardeners, builders, etc., etc., in all the forms of personal expenditure?
>
> Under what circumstances is personal thrift socially desirable?
>
> With working capital, raw materials, labor, managerial ability, factories, and equipment all ready to run, why can't we run, particularly when laborers, management, and all concerned are only too anxious to appear as prospective consumers of the goods produced?

Now all these questions are simple in appearance, direct, and intensely practical. They represent the first thoughts that would come into the mind of any one who is concerned with improving social conditions in the industrial field. Of whom shall we ask them?

Not of the old-style professional economist. Some of the questions are too raw and elemental to be attractive to him as objects of dignified cerebration. Others he will condescend to consider, and be willing to give answer to; but his fellow-economist will give a different answer, and a third will give still a third. In questions of this type—that is, immediately practical questions—there is such a lack of unanimity as to indicate that in these matters economics is far from being a true science.

Whom, then, shall we ask? Why not the practical men—the financiers? It is very likely that one of the serious elements of the problem lies within their purview. The monetary system is complicated and difficult to understand. Perhaps in its present form it is dangerous as well. Men like Sir Josiah Stamp and Professor Fisher think so, at least. There may be a mechanism here that is ripe for radical redesign. Or, the difficulties may be those of unskilled manipulation.

The bankers will give answers, each according to his kind; all with an attempt at honest thought, but often colored by their immediate interests or emotional reactions—as may happen to any of us. It will be particularly difficult for the layman to translate their opinions and recommendations into terms of general social welfare. An interpreter is sadly needed. Furthermore the steady drift toward making the sale of securities the principal source of banking profits (as is the case in most of the large city institutions) has made it increasingly difficult for them to give disinterested advice of any kind with the best will in the world.

What about the statistical collector and reporter—the specialist in business conditions? His mind appears to be on other matters. His highest ambition is to predict successfully. What we are interested in is *control.* We don't want merely to foresee hard times; we want to prevent them, and as engineers we are confident that it can be done. Yet if any progress is being made at the present time it is being made by this group of statisticians and forecasters. There must, however, be some essential elements of the problem which have escaped them. The material situation is simply riotous in the richness of its possibilities, while forecast and guidance are pitifully meager.

Can the practical business man help us? Alas, it is he, and the men and women working for him, who are asking the questions. On the whole, during the last five years he has played the game. The prices of his output as a whole were not raised, wages were not lowered. In particular, during the height of the speculative boom he continued his hand-to-mouth buying, adding not at all—as a class—to the pyramiding pile of orders, commitments, swollen stocks, and speculative purchases, in all of which in previous crises he has been one of the principal offenders. The productive business man is very properly resentful at having been betrayed in spite of his intelligent and socially minded course of action.

In only one respect is he open to criticism, and that is in having lent his cash reserve in some instances in the call market during the height of the speculation. I venture to predict that he will not do this again. The proceeding has left a bad taste in his mouth.

The manufacturer and productive business man want to play the game, and they are asking these questions—not answering them.

By no means would we hope for light and leading from the stock broker and market speculator. Here we meet the direct antithesis and negation of all we hope for.

Consider but this one matter. In September last the New York dailies informed us that the new high-speed stock tickers had been completed and installed. Engineers and inventors had solved the problem of doubling the rate of transmission. It was stated in the news columns that these machines would take care of a ten-million-share day. It was also stated that Wall Street is certain that the ten-million-share day will come again, that "the public" will again push and crowd into the market and revive the glorious days of 1929.

What disturbing hopes! What cynical and sinister preparations! It matters not whether the ten-million-share day is a cause or an effect—the lesion itself or a revealing symptom. Its return will solemnize a defeat in the history of the human spirit. In times of unbridled speculation, man clouds his own vision, stops his ears, drugs his social sensitiveness, wrecks the mechanism of his intelligence, lets slip from his nerveless hands the steering wheel and the controlling levers which history has designed for his highest functioning—

and the deliberate, easy, natural every-day sort of a preparation for this calamity is an interesting but unimportant "story" in the morning paper.

The politician cannot help. He is just one of us who has received a certain number of votes. He is not made keener, wiser by those votes. It is doubtful, indeed, if the problem is capable of political solution except in its details; but there will undoubtedly be a place for the same kind of legislative statesmanship which produced the Federal Reserve bill.

Of all these classes it seems hopeless to demand an answer; yet there are many who, unasked, are eager to reply. These are the amateurs with preconceived social panaceas, individuals with strong emotional reactions or insistent vested interests. I can give quick answers myself to some of them based on such impulses as these—but such answers do not satisfy. We want the cool, objective, impersonal, scientific viewpoint, and that, apparently, is not available from any existing source. We are waiting for the unborn "social engineer."

I have indicated my hopes as to his parentage, and my expectations as to the place of his birth. May I further predict that he will live a troublesome and difficult life.

TIMES RIPE FOR THE "SOCIAL ENGINEER"

The engineering profession of which we are members has had a sheltered existence. In our personal relationship there has been much of difficulty, much of sorrow, many emergencies requiring all our courage and endurance. In our work as engineers, on the purely engineering elements of our work, this has not often been the case. We have dealt with forces, strains, stresses, thermodynamics, relative motions, structures, laws, and mechanisms. We deal also with costs, efficiency, durability, and safety. It has only been in occasional contingencies involving the second category of items that personal relations have had an important bearing and emotional reactions have become effective in professional life.

But pity the "social engineer." In the first place, there is no highly remunerative work waiting for his special services. The basic research and analysis will have to be done, like all scientific work, from pure love and enthusiasm for the subject; and the subsequent passing on of the new technique will have to be in the form of a socially useful infusion into the immediately profitable training in business and financial procedure. In the second place, the whole field of investigation is swamped with vested interests and emotional reactions. In addition to the essential qualities of intelligence and concentration, a high degree of courage will be needed. But courage has never yet been lacking when there was good work to be done.

We may predict that when the solution is formulated, it will be found to consist of changes of viewpoint and new rules of action for all of us, whether bankers, manufacturers, workmen, or what not. The nature of the change and the means by which it will be brought about will doubtless parallel that effective resistance to temptation on the part of business men which kept so many of them in this last crisis from speculative overstocking and overordering. Many of these new practices will appear to go against immediate self-interest. But the larger and broader view will win out as it has in the past.

The times are indeed ripe. There is a growing community of interest and feeling between the manufacturer and the workman. The farmer, too, with all his perplexing problems has come into the picture, for the real markets of the American manufacturer lie in the homes scattered throughout the land which lack that share of the necessities and luxuries to which the industry and ability of their occupants entitle them.

It is a dangerous and uncertain employment of our alleged excess productive capacity to depend upon greatly extending our foreign trade. So far as this can be done to the mutual satisfaction of all parties, it is desirable. But usually there lurks concealed within the idea some element of one-sided advantage—some suspicion of exploitation. Frequently do our political actions give definite point to such suspicions. And there is always the uncertainty of foreign conditions—unrest and our own involvement (voluntary or involuntary) in their political maneuvers. Organizing to fill the needs of our own fellow-countrymen must engage our first attention for the years to come.

FORCES IMPELLING US TO A MORE CONSTRUCTIVE SOCIAL ACTIVITY

In making this plea for a new profession, a new training, and a new career, it is safest to paint the prospect in the colors of enlightened self-interest. This will carry us far—much farther than we are likely to go in the next decade. But let us not entirely disdain the more ideal motives.

We have reached the point in the history of our civilization when such questions as we are now considering demand their answer in a most peremptory voice.

Until this time we have been led by blind forces. Invention, science, engineering, industrialism, and natural opportunity have combined to lay out a course which we have followed with headlong enthusiasm. This course has led us through a period of unimaginable development, and has brought us social and individual benefits of the material kind to a degree for which we find no parallel in the records of the past. But with these blessings there has come (as is the way with such blessings) this attending train of problems and perplexities.

We have no reason to believe that these problems will settle themselves. On the contrary, most thoughtful people are concluding that we have reached the end of unconscious natural adaptations—of automatic blessings of all sorts. Our safety and progress from this time forth depend on self-conscious, carefully planned, purposeful action. We are still children of Nature, subject to her laws and reacting to her influences, but we have attained social maturity; and henceforth our adaptations must of necessity be made in the light of experience and by the exercise of our keenest intelligence.

It is not intended to expand this idea here this evening, important though it certainly is. It would need a chapter by itself—a whole book—for its proper presentation. The passage from sheltered youth to responsible maturity, from unself-consciousness to self-consciousness, from culture to civilization (in the sense in which Spengler uses the terms) demands a new viewpoint and a new technique.

There is another powerful influence driving us to a more constructive social activity. There is in Eastern Europe and Northern Asia a power of definite and purposeful ideals and amazing vitality. That power is challenging our own civilization. The challenge is not to armed conflict, but to a contest in the achievement of human welfare. That power well knows that it starts far back in the race, but its supporters have intelligence and a well-tested enthusiasm. Above all they intend to be conscious, directing elements in their own history. It simply will not do for us to be carelessly confident. We have unwisely and too long nourished our self-esteem with predictions of their early failure. This situation gives edge and point to our problem, though it should by no means be our only spur to action.

And the environment is most favorable. Our country is the predestined seat of solid social progress. It is large, varied, and self-contained. The population is great enough to furnish ample markets for every desirable commodity, and ample markets are necessary to efficient production and distribution. There is here such a variety of climates, such a range of resources, such wealth of environmental diversity as to sharpen our ingenuity and challenge our skill. In accessible profusion within our own borders are to be found most of the essential materials of modern life. The reserves of the basic substances—coal, oil, and iron—put us in a specially favored class of our own. Our soil is fertile, not intensively cultivated as yet, and distributed with a prodigality which is almost embarrassing. Timber is diminishing, but there are thousands of square miles suitable for its cultivation and good for little else. The necessary unprovided materials are few: rubber, tin, and nickel come easily to the mind. If necessary, the first could be made synthetically or of native materials at an increased price, and probably will shortly be so made in any event. Tin and nickel present more difficult problems, being examples perhaps of permanent dependence on outside supply.

In the luxury class there are, of course, many other substances for which we must look to the outside world—or at least to dependencies outside our continental borders. Tea, coffee, silk, platinum, and diamonds (these last two are also of great industrial importance) are among the commodities for which we must probably remain dependent on overseas transportation. But how meager is the list of necessities, or even of the accustomed luxuries, which Nature has withheld from our soil!

Lastly, and in something quite other than a boasting sense, *we are the people!* Drawn from varied races, modified by diverse environments within our far-reaching political boundaries, we are yet blessed with such a sense of unity in our diversity as makes common action possible if difficult, and gives fertility and richness to the multitude of our interactions.

THE BEGINNING OF THE GREATEST ADVENTURE IN SOCIAL HISTORY

These are large words, resounding phrases, statements which stir the imagination. Yet they furnish poor fuel for the fires of pride and poor building material for the skyscraping towers of arrogance.

We are what we are, and we have what we have for reasons quite other than our own deserving merit. It was the secret, complex, and resistless flow of the stream of history, with all its eddies, undertows, and oscillating tidal sweeps, which assembled us here on this continent with our useful diversity of viewpoint and capacity. It was unaided Nature, to give it no higher name, which prepared the rich and diverse geographical environment. It was the incomprehensible Moment in the Scheme of Things which released the twin forces of science and invention in time to bring their offspring, engineering, to full maturity in the midst of this people.

This conjunction of the fullness of time, the well-provisioned place, and a varied, dynamic, yet united people is a serious responsibility. It is with a deep sense of this responsibility that this paper has been prepared and is being read to you this evening.

In simple truth, there is no arena for the highest ambition which compares with this now before us. It is doubtless pleasant to be a millionaire—but they have become so common. Even billionaires, however worthy they may be, are not the objects of veneration they would have been a generation ago. As for research into the past, or present enjoyment of its accumulated treasures, that is all very comfortable and commendable.

But here is offered a unique and tremendous task, with all the materials and all the tools provided. We are invited to organize human society on the basis of human well-being, and the next step is this one of controlling the economic environment.

Engineers have provided the tools and methods to make it physically possible. The growing consciousness on the part of workers, farmers, and productive business men that they have a common interest in the matter, begins to make it humanly possible. If there are sections of society whose interests appear to be opposed, they cannot long stand in the way—nor, in the light of a clearer vision, will they want to.

Let then the young and clear-headed and brave-hearted join together an extended science and an improved practice, under the fostering care of the new schools, and effectively attack the problem of economic control.

It is the beginning of the greatest adventure in social history. We must see it through.

The Economist's View
—By Dr. Wesley C. Mitchell[3]

MR. FLANDERS has presented admirably one of the greatest paradoxes of contemporary life. At the present moment several million men in the United States are seeking vainly for jobs. Business enterprises by the thousand are standing idle or running part time. Their managers are as eager to produce as the unemployed are eager to work. On the other hand, the very people who would like to be at work are suffering from lack of food, shelter, and clothing. There is no material reason why these people should not get busy and provide what they desperately need. Raw materials are superabundant, productive equipment stands ready for use, technical skill is not lacking. Yet, somehow, we cannot as a community do what we all wish to.

INEFFICIENCY OF OUR ECONOMIC ORGANIZATION

The factor which is thwarting our desires lies in our economic organization—that elaborate scheme which intervenes between men as producers and the same men regrouped as consumers. Engineers are prone to speak of this economic organization as a piece of social machinery, and to think of the economic machine as the most defective part of our equipment for living.

Cyclical depressions like the present show the inefficiency of our economic organization in its most glaring form. But these depressions are transitory. During the last half-century in this country we have had 15 periods of business contraction, counting in the present one. The longest lasted 38 months; the average duration has been 18 months. But only 6 of the 15 have been comparable in severity with the current episode—namely, the depressions of 1884–85, 1893–94, 1896–97, 1908, 1914–15, and 1921–22. If we count only the months during which business was depressed in somewhat the same measure as it is depressed at present, we find that these months make up about 7.5 per cent of the last 50 years.

But the inefficiency of our economic organization is not limited to these transitory periods of cyclical depression. The fact is that in good times as well as in bad our economic organization prevents society from producing as large a real income as natural resources, man power, plant capacity, and engineering skill make possible. In an article which Mr. Flanders published in the *Forum* for November, it is said: "The engineer knows—all engineers know—that, if some omniscient dictator were installed as ruler of the United States, they could provide for him raw material, machinery, and trained labor sufficient to flood, bury, and smother the population in such an avalanche of food, clothing, shelter, luxuries, and material refinements as no Utopian dreamer in his busiest slumbers has ever conceived. The material conditions for productivity are already here, but to control the economic machine we need more than the ability, the means, the raw materials with which to produce. We need understanding on the part of the economists, and this we have not got."

GROWING INTEREST OF ENGINEERS IN ECONOMICS

All this which Mr. Flanders sets forth so effectively is an old story to economists—even to their own lack of understanding. I could parallel point after point in the engineering analysis by quotations from economic literature. To give just one example: let me put beside Mr. Flanders' passage from the *Forum*, a passage from Thorstein Veblen's book, "The Engineers and the Price System," published in 1921. Veblen remarks (pp. 70–71), ". . . It is an open secret that with a reasonably free hand the production experts would today readily increase the ordinary output of industry by severalfold—variously estimated at some 300 per cent to 1200 per cent of the current output. And what stands in the way of so increasing the ordinary output of goods and services is 'business as usual.'"

What *is* relatively new is that engineers are beginning to concern themselves seriously with the workings of the economic machine. That is a most auspicious development—one which economists will welcome. I offer only one amendment to Mr. Flanders' suggestions. I hope that engineers will join with economists in working on the problem of economic organization, and not merely call upon the economists to produce the science and the art which is needed. By way of persuading you to help, I shall try to show how big and difficult this construction job is.

THE WORKINGS OF THE ECONOMIC MACHINE

Let me begin by sketching certain features of the economic machine which intervenes between ourselves as producers and ourselves as consumers.

In order that the production, distribution, and consumption of goods may proceed smoothly in a country like ours, it is necessary that the whole congeries of industrial and business processes be kept in due adjustment to each other. The goods turned out by producers must find purchasers at remunerative prices. This means that the prices paid for raw materials, incidental supplies, fuel or electric current, manual and clerical labor, professional and managerial services, technical equipment, real estate and loans, each factor multiplied by the quantity used per unit of product, must be kept in due adjustment to the unit selling prices of products, each multiplied by the number of units turned out. This price adjustment must be maintained at every stage in every branch of production: the raw-material producer, the warehouse man, the merchant, the railroad, the building contractor, the manufacturer, the jobber and wholesaler, the retailer, the insurance company, the bank, the broker, the architect and engineer, the lawyer and doctor, the laundry, hotel, and theater must get a price margin per unit above unit expenses, which, when multiplied by the number of units sold, will yield a net income enabling the recipient to buy the products of others. These money incomes realized by wage and salary earners, professional men, farmers, investors, and business enterprises must be kept adjusted to the profitable selling values of the goods sent to market. Note that this adjustment of values is not merely a matter of prices; it means also that the physical quantities of the myriad forms of goods turned out must be adjusted to the physical quantities which need or taste will induce consumers to buy at profitable prices. Further, the productive capacity of the industrial plants of all sorts must be adjusted, and usually adjusted well in advance, to turn out the physical quantities of goods which the market will absorb at profitable prices. That means, in turn, that a balance must be preserved between what we commonly refer to as spending and saving. By way of further complications, business enterprises are held together by financial arrangements—and they, too, present problems of adjustment. Enterprises must be provided with credit adequate to enable them to take advantage of profitable opportunities; if the credits granted are superabundant there is danger of reckless speculation, ending in an epidemic of bankruptcies among borrowers and lenders alike. In their turn the banks must keep a proper balance between their liabilities and resources, particularly between their demand deposits and their reserves.

---

[3] Director of the National Bureau of Economic Research, New York, N. Y.

Now all these adjustments, and others I might mention, have to be maintained by the unplanned reactions of a host of agencies. In the United States there are perhaps ten million individuals, partnerships, and corporations engaged in business, each upon his or its own account, and each seeking primarily his or its own gain. There are, say, forty-five million individuals with money incomes, each of whom is nominally free to spend his money as he likes. Perhaps a quarter or a third of these consumers are also investors, free to share in directing the flow of the country's savings into whatever channels they think profitable. So, too, every worker is legally free to enter any trade, profession, or business in which he can get foothold, and so to exercise his infinitesimal influence upon what is produced. Every individual competes with other individuals for jobs, or customers, or goods, or investments. The whole situation looks anarchical. Within a business enterprise there may be most admirable planning of work, with skilled leadership and due allocation of responsibilities. But as between independent business enterprises there is no common leadership, no plan of operations. Mr. Flanders expresses this idea by saying that the economic machine was not designed. He is right. It is merely the outgrowth of social evolution up to date. It works after a fashion, as must all human arrangements which survive in the struggle for existence. How it works is as much of a mystery as animal life.

The mystery deepens on reflection. Most of the factors which must be adjusted to each other are growing; but they grow at very different rates, and the rates of growth keep changing. A few factors are shrinking. Methods of industrial production, methods of marketing, forms of business organization, tastes of consumers are continually being altered. Novel products are being launched upon the markets every year, making matters more difficult for producers of old products. Mechanical engineers are among the most violent disturbers of the business peace. Add to all these changes brought about by man from economic motives the changes arising from our social, political, and religious strivings; from the new ambitions, scales of value, and standards of propriety which each "younger generation" develops in its turn. Add, too, the incalculable changes which Nature works—particularly the variations from year to year in the supply of raw farm products. To keep all the myriad processes of economic activity even tolerably adjusted to each other seems an almost impossible task in a system where there are millions of independent authorities, no concerted plan of action, and where every factor in the situation is subject to change without notice.

Thus the real mystery is not that the economic machine—if we are to continue calling it that—now and then gets badly out of order; the mystery is that most of the time this machine runs after a fashion. And this is the mystery upon which economic theorists have centered their attention. They commonly picture each individual as maintaining a double balance in his own affairs: first a balance among the marginal satisfactions he gets by spending a dollar for goods of different types—food, clothing, shelter, education, medical services, amusements, and so on; second, a balance between the marginal sacrifices he undergoes in making a dollar, and the marginal satisfactions he obtains from consuming the goods he can buy with a dollar. These individual balances afford an automatic control over the complicated economic processes of a great society. As productive effort becomes more efficient and pressing needs are tolerably well met for the most part, men choose not to work such long hours as formerly. So the standard working time drops from twelve hours a day to ten, to eight, to forty-four hours per week, to forty hours. On any level of productivity, the prices individuals are willing to take for their labor and their saving, on the one hand, and the prices they are willing to pay for consumers' goods, on the other hand, determine what can be produced at a profit, and so guide industry in all its ventures, even to the building of plants to make machines which will be used to make more machines. If more of any product is produced than can be sold at an acceptable profit, then the marginal producers must turn to some other type of work or be forced out of business; the supply is diminished and prices return to a remunerative level. If the supply of another product is less than the demand at profitable prices, the output is increased and prices decline. Thus the economic mechanism, though designed by no man, tends to correct disturbances of equilibrium which interfere with its smooth running.

The gyroscopic-like adjustments, however, which the machine makes automatically, are not always prompt. After a severe jolt the machine may take some time to right itself, and a new disturbance may occur before the first has been compensated for.

Of course this is a most inadequate sketch of an elaborate body of close analysis. I fear it will not have even suggestive value to those of you who have not read a modern treatise on economics. But some explanation is needed of the way in which our economic organization works. Before trying to remedy the defects we may see in the machine, it is well to ponder this current explanation of its fundamental principles. It is my own opinion that this explanation must be improved before we shall know enough to make the machine work as we should like. That is a task upon which we and our children are likely to be working to the end of time. Meanwhile we must do the best we can in our own generation to improve both our economic knowledge and our economic practice. That we cannot do a perfect job until we have perfect knowledge is no excuse for not doing the best job our imperfect knowledge permits. One of the best ways to increase knowledge is to apply what knowledge we have.

Difficulties Presented by Economic Problems

On the whole, that has been the line taken by economists. They have been critics of economic organization—constructive critics and would-be reformers. Some of the ablest economic theorists have held the whole capitalistic system to be an incubus upon humanity which must shortly be shuffled off, as feudalism was. The great majority have contented themselves with trying to improve details. They have worked for stable monetary standards, for efficient banking systems, for social-insurance schemes, for government regulation of public utilities, for freedom of commercial intercourse, for restriction of parasitic trades, and so on. Thus economists have sought to practice social engineering from long before the days of Adam Smith to the present year of grace. Most certainly they will continue that practice in the future, and here, too, they would like the help of engineers. But they know from long experience that the difficulties of social engineering are many.

Most fundamental are certain intellectual difficulties. First, economists have come to realize, at least in their calmer moments, that their analysis—what they like to call their "science"—never tells what ought to be done. At most it tells that if a certain thing is done, some other thing will follow. It does not tell whether this thing which will follow is good or bad. That question has to be decided on grounds of enlightened common sense, elaborated at need into a system of social ethics. Second, no one can define the basic concept of social ethics, namely, social welfare, in such a way as to make it a satisfactory working criterion of what ought to be done. At most we can get agreement among a large number of intelligent people that certain results are desirable—say, a decline in illiteracy, a rise in average real income per capita. When only a few people challenge our aims we can disregard them. But we can seldom disregard a large minority in social matters. This means that we can make headway with economic reforms only so fast as a large part of the public gets enlightened enough to sustain us, or we get enlightened enough to carry a large part of the public with us. Third, any economic change proposed will produce a host of reactions besides those which the sponsors aim to produce. It is usually difficult to foresee all these reactions, to be sure whether those we do foresee will augment or diminish social welfare, and so to estimate the net gain or loss promised by our proposed change. Economists acquainted with past experience tend to be rather cautious in their expectations of the net gains from given changes—often so cautious as to alienate the sympathy of ardent reformers.

But there are plenty of occasions on which economists surmount or disregard these difficulties, and come out boldly with proposals for changes in economic practice. What happens then?

A mechanical engineer who has developed a good idea may have trouble in getting it adopted. But history proves that you have been remarkably successful on the whole. By the often-repeated demonstration of the advantage of improving mechanical equipment, you have taught the world to accept your advice—and pay for the privilege of getting it. You can appeal to the profit incentive. If you persuade a single business enterprise to adopt a change, and the change works well in practice, competition will force that change upon a whole industry, unless in the meantime some other engineer has devised a still better method.

The man who urges a change in economic organization encounters all the obstacles which hamper technical changes in engineering, plus others. Usually he must convert, not the management of one business enterprise, but thousands or millions of men. He can't promise to make a fortune for any individual of the lot, though he may claim that his idea will add appreciably to the well-being of every family in the country. Almost invariably his project will endanger certain vested interests, and they will attack him tooth and nail. He must defend his cause against these opponents, and carry on a campaign of education to enlighten and arouse the indifferent majority. That costs a deal of money. Unless he has riches to devote to his cause, he must raise funds from sympathizers on the basis of a quasi-philanthropic appeal. But these are generalizations which do not apply strictly to every case and which do not register vividly in every mind. Let me give a concrete instance or two.

There are few practical issues upon which economists are more nearly unanimous than upon the effects produced by levying tariff duties on imports. We think that reasoning and analysis of experience support the view that, apart from a limited range of cases, a tariff tends to check the increase of average real incomes in the country which levies it, as well as in other countries. We further think that hampering the rise of averager real income is undesirable. Our opposition to protective tariffs has done more than any other one thing to give economists the reputation of being impracticable theorists. I dare say many of you are now protectionists; but I dare to say also that when any scientifically minded protectionist becomes well acquainted with economics, he will shift his ground. Tariffs may be defended on military grounds, as reprisals in commercial warfare, as means of raising revenue, as pabulum for infant industries, or, when they have been in force for a while, as crutches on which a warped industry has become dependent. No American economist would counsel an immediate repeal of all our tariff duties. But the system as a whole has been built up in the face of strenuous criticism by economists. What my profession thinks of the latest tariff act was shown by the memorial signed by more than a thousand economists last spring, asking the President to veto the bill passed by Congress. You know how far we got in that attempt to practice the art of social engineering. If you join us in this campaign for economic reform, perhaps our joint forces, aided by the trend of developments, will accomplish more.

Take another example: At the present time, geologists and mining engineers tell us that the annual world output of gold is more likely to shrink than to expand within the next generation. If it does shrink, past experience and economic analysis indicate that there will be a secular decline of the price level in gold-standard countries, like that which occurred between 1873 and 1896—unless changes of various sorts are made in economic practice. We can show with some confidence what the direct and indirect consequences of a secular decline of prices will be. There is common agreement that the net effects will be unfavorable. Economists have suggested ways of averting these dangers. These suggestions are now being studied by the Gold Delegation of the League of Nations—a body made up of experts on monetary problems from eleven countries. Suppose that these doctors agree upon certain remedies, or palliatives, as seems not unlikely. Most if not all of the measures they are likely to recommend will be ineffective unless common action is taken by several of the largest gold-standard countries—at least Great Britain, Germany, France, and the United States. To do social engineering of a fundamental sort in monetary policy thus requires converting the various parties at interest to a common purpose on an international scale. Perhaps you know how easy it is to effect international agreements.

WHY ECONOMICS HAS NOT PROGRESSED MORE RAPIDLY AS A SCIENCE

I have stressed the difficulty of economic problems, as in duty I am bound to do. The fundamental trouble is that economics deals with the most complicated of all materials—human behavior. Man is an animal, all animals are complicated, *homo sapiens* is the most complicated and variable of the lot. He is a creature of slowly changing habits, of loves and hates, of wild impulses, as well as a creature with some capacity to reason. And a scientific inquirer can't experiment on men very effectively. They object.

All that I have said can be taken as an explanation of why economics has not made more rapid progress as a science and as an art. It is not an apology for the past. Nor is it a prophecy of the future. Indeed, I think we have rational grounds for believing that economics is now making more rapid progress than it has made since the generation that followed the Napoleonic wars. My chief reason for optimism is that the records of human behavior, regularly collected and published, are becoming fuller and more accurate. That fact makes it possible for economists to observe what happens far more accurately than their predecessors could. In dealing with many, though not with all, problems we can now substitute knowledge of fact for uncertain opinion; analysis of actual processes for speculation about what would happen under hypothetical conditions. We can measure many factors. We can test more of our theories. Further, our sister sciences of human behavior—psychology, political science, sociology, anthropology, history—are gaining in reach and in power. We are cultivating closer relations with them and profiting by what they have to teach about that curious animal, man.

ECONOMISTS MORE AND MORE ENGAGING IN PRACTICAL AFFAIRS

It is also of good omen that economists are getting more chance nowadays to engage in practical affairs. Most great banks and financial houses, many great industrial corporations, employ economists as aids to their general executives. Presumably the business enterprises profit by this policy; certainly economists profit by opportunities to become intimately familiar with many branches of trade. Government agencies—local, state, national, and international—have their staffs of salaried economists dealing systematically with current problems; they frequently call upon outside experts for technical advice. Legislative committees follow suit.

Perhaps most interesting of all these developments are the efforts of the engineer now in the White House to lay a scientific basis for social engineering. So far as the pressing exigencies of a great political office permit, this engineer follows the procedure characteristic of his profession—methodical study of needs to be met, the preparation of working plans by technically qualified experts, a review of these plans by consultants, followed by an effort to put the matured plans into effect. For the reasons I have already explained, this procedure as applied to social problems cannot be carried out with the smoothness and precision of ordinary engineering work. Mr. Hoover's Committee on Recent Economic changes, his Research Committee on Social Trends, his Conference on the Health and Protection of Children, his Conference on Home Building and Home

Ownership, his National Advisory Committee on Illiteracy, and his National Law-Enforcement Commission are dealing with far subtler problems than would face an engineering commission. It is by no means certain that all of these bodies will agree upon definite plans of large significance. Whatever recommendations they submit must run the gauntlet of heated discussion by people who are not experts. The immediate results attained by the whole program may not be large But that a president of the United States should venture to apply the procedure of scientific technology to social problems is a hopeful portent to all who believe that man's best chance of bettering his lot lies in using his brain. Whatever is learned from the present series of experiments can be applied to make the next series of experiments more successful. And the cumulative character of scientific advance gives us ground for expecting that what seems a bold experiment to our own generation will be accepted by future generations as the obviously desirable procedure.

Actual Conditions Seen by Social Workers vs. Possible Conditions Seen by Engineers

If I am right about the present status and prospects of economics, theoretical and applied, then engineers have an opportunity to enter the campaign under auspicious conditions. They will find that much of the current literature of economics presents data of keen interest to them, analyzed by methods similar to certain procedures of their own. Without a great expenditure of time and effort upon preliminaries, they can take whatever share they like in the constructive work going forward.

To that work they can give a great impetus Let me explain how. Last June I attended the National Conference of Social Work in Boston. I found the social workers deeply concerned about the inadequacy of average real incomes in the United States. They have given much attention to determining what it costs to keep a family of father, mother, and three children on a standard which provides for maximum physical efficiency. Allowing only for the purchase of what they regard as bare necessities for efficiency, at prices prevailing in the last two or three years, the investigators get figures running somewhat over $2000 per annum. Against this family requirement of, say, $2100, the social workers set the current estimates of average earnings in various industries. The latest, most comprehensive, and probably the most reliable approximations to average annual earnings are those made by Paul H. Douglas, in his book on "Real Wages in the United States." In 1926, the latest year covered, Douglas finds average annual earnings of $1309 in manufacturing, $1613 on steam railroads, $1566 on street railways, $1477 in gas and electric works, etc. His grand average for all industries is $1376. He finds only two groups of workers for which there are data with average earnings exceeding the estimated cost of maintaining the physical efficiency of a family of five. These two groups are postal employees and clerical workers in factory and railroad offices. In short, the social workers point out that there is a wide gap between average earnings and the cost of keeping a family of five physically fit. A vast number of American families on that showing are underfed, inadequately clothed, and poorly housed, even in a good business year like 1926. For things like fresh lettuce, washing machines, and radios, these families are not in the market at all. The cost of such articles is not included in the budget. As for a bad business year, we have the deplorable facts before our eyes.

For the Boston meeting, I made some calculations which seemed to show that the spokesmen for the social workers were exaggerating the gap between earnings and the cost of living; but my qualifications did not close the gap. The social workers are right in saying that the American population has vast unsatisfied needs, judged by the criterion of physical efficiency—not to speak of desires. Many billions of dollars must be added to our national wage income if we are to give a fair chance of physical and mental development to all our children.

It is striking to recall this discussion with social workers, who are beset by the grim realities of widespread poverty, in the present discussion with engineers, who are cheered by a vision of possible plenty for all. Let me repeat Mr. Flanders' strong statement once more:

"The engineer knows—all engineers know—that, if some omniscient dictator were installed as ruler of the United States they could provide for him raw material, machinery, and trained labor sufficient to flood, bury, and smother the population in such an avalanche of food, clothing, shelter, luxuries, and material refinements as no Utopian dreamer in his busiest slumbers has ever conceived."

Now, if Mr. Flanders is right, if you all know that it is feasible from the engineering viewpoint to abolish poverty, then you should present this stirring possibility to your fellow-countrymen with all the force and persuasiveness in you. By so doing, you could concentrate attention upon the need of improving our economic machinery more effectively than any other set of men. An emergency like the present time of unemployment effects such concentration and puts many minds to work upon the task of relief. You could do something finer: fix attention, not on the mitigation of a temporary emergency, but on the attainment of a far higher permanent level of material comfort for all mankind. Join your knowledge of the technical possibilities of production with the social workers' demonstration of the crying need of more food, more clothing, more shelter, more of all the goods which minister to physical efficiency, and you have an overwhelming case for inventing some way of enabling the millions of families which need more goods to buy the surplus products which are the nightmare of business men, plus the additional goods which hover in your day dreams. Mr. Flanders has said that we have a vast potential market in needy American homes. The social workers' calculations support that contention. If there are millions of needy American families, there are hundreds of millions of needy families in foreign lands. All that is needed is to enable these families to buy. But how can we do that? Must not the recipients of purchasing power give a *quid pro quo*? Must they not render some service which others are willing to receive in return for their own products? What services can the needy ones render which the efficient producers will accept?

Thus I come back at the end to Mr. Flanders' starting point. Of course I have not solved the problem he sets to economists. Nobody can solve that problem at present. I have merely tried to make clear how many difficulties must be surmounted in working out a solution and putting it into practice. The problem centers in the workings of a vast social machine. More accurately put, it concerns the economic behavior of millions of men. We must understand this behavior better than we do now before we can have much confidence in any new schemes we may invent. Plans which disregard the fixities and foibles of human nature will not work. Mr. Flanders suggests that an "omniscient dictator" might solve the problem. Thorstein Veblen suggested a soviet of engineers. The Russians are trying a committee of doctrinaire communists served by technicians. All such schemes imply that we, the mass of mankind, shall surrender to some higher authority our economic liberty to do whatever kind of work we can get a chance at, and to buy whatever kind of goods we can afford. Perhaps we should be better off in a material sense if we made that surrender. Perhaps we overvalue our present liberty of choice. In large part it is illusory, for many of our present choices are forced upon us by circumstances which we do not like. But we are accustomed to our present set of institutions. As human affairs go, we have prospered in this country. Getting us to change our habits for something better will involve re-education as well as invention. And re-education is a slow process.

Slow; but not hopeless. The very drift of affairs is coercing us to change. Why not mix all the intelligence we can muster into this process of making over our own habits, as we put intelligence into the continual rebuilding of our industrial plants? In fact we are doing just that with increasing skill, generation by generation. If engineers will join with the other professions who are working on the problem, we shall get on faster. For the present workers need a clearer vision of what is possible in production, and a more constructive attitude of mind. Those needs engineers can supply.

The Callendar Total-Heat–Entropy Diagram

THE new Callendar total-heat–entropy diagram published by Edward Arnold & Co., London, is the last compilation of data on the properties of steam prepared by Professor Callendar before his death. It is lithographed in three colors, carefully drafted, and registered, and the variety of colors makes it possible to include in the superheat region lines of constant pressure, temperature, superheat, and volume on top of a 2-mm. square coordinate grid without confusion. Doubtless many engineers will prefer this comprehensive type of chart (price, 4s. 9d. postpaid) to the more conservative black-and-white chart which usually omits the constant-volume lines.

Some confusion may possibly result from the subtitle, "Plotted by Prof. H. L. Callendar, F.R.S., From His Extended Steam Tables, 1930." The chart really represents Callendar's last revision of his equation of state, the tables from which were published in 1928.

The Callendar tables have appeared in three forms: first, the Callendar steam tables of 1915, second, the enlarged Callendar steam tables of 1924, and third, in a paper presented to the Royal Society in 1928, entitled, "Steam Tables and Equations Extended by Direct Experiment to 4000 Lb. per Sq. In. and 400° C."

The 1915 publication corresponded to the original Callendar equation of state. The 1924 publication was the same extended to 2000 lb. per sq. in. The 1928 publication, which corresponds to the chart under consideration, is based on a complete revision of the Callendar equation in the light of Professor Callendar's own experiments at high pressures. So far as the writer has been able to determine, this new equation has not been explicitly stated in the Royal Society paper, but the values computed from it are quite different from those obtained from the older equation. For instance, the total-heat–entropy diagram corresponding to the old equation showed a saturation line with a gradually increasing total heat even at the 2000-lb. per sq. in. line where the chart ended. The saturation line on the new chart reaches a maximum at about 550 lb. per sq. in., which, though a somewhat higher pressure than that given by the Keenan or the Knoblauch tables, is nevertheless approaching agreement. Radical changes have been made in magnitudes as well as characteristics, the specific volumes at 2000 lb. per sq. in. being altered nearly 10 per cent.

In our present state of uncertainty with regard to heat units it would be well if compilers of steam tables would include in every table and chart a definition in terms of absolute or electrical units of the heat unit adopted. Professor Callendar's B.t.u. is unexplained unless one searches his publications for the elusive equivalent. Perhaps we shall some day bring about general acceptance of the international calory and the international B.t.u., the definitions of which will be found unequivocally stated in all handbooks and dictionaries of engineering and physics.—J. H. Keenan.

Low-Cost Peak-Load Capacity With Bleeder Turbines

Methods of Carrying Peak Loads in Central Stations—Proposed Peak-Load Plants—Plant Performance—Plant Costs—Capacities—Other Systems With Water Storage—Systems With No Water Storage

By A. G. CHRISTIE[1] AND WARREN VIESSMAN,[2] BALTIMORE, MD.

CENTRAL-STATION management has always been confronted with the problems of large plant investments to meet maximum demands and with low use factors due to peak loads. The problem of supplying peak-load capacity at minimum cost has been attacked more or less successfully and solved by various methods, several of which will be briefly discussed. This paper will consider particularly the possibilities of modifying bleeder-turbine operation to provide low-cost peak-load capacity in central stations.

METHODS OF CARRYING PEAK LOADS

With the growth of the electrical power industry, new plants of more modern design and greater economy have been built, resulting in the older plants becoming uneconomical for continuous operation as compared with the later installations. In many cases the old plants have been dismantled to make room for new installations. In other cases the older stations have been retained for use as peak-load plants during the daily or seasonal peak loads. This method of supplying peak-load capacity has the disadvantage that the peak load is not generated as efficiently as the base load. However, as the value of the older plant is generally written down to a low figure, the plan has certain financial advantages in small fixed charges for such peak-load capacity, while the higher fuel consumption for short peak-load periods is not a significant factor in the total system costs.

The use of hydraulic storage is another method of supplying peak loads and will doubtless meet with success under favorable conditions. This method has been utilized in Switzerland, Germany, and Austria during the past few years. One of the latest installations is in connection with the Herdecke super-power station in the Ruhr district of Germany.[3] With this method, water at low head is pumped into high-head storage reservoirs during the off-peak hours, and is utilized in carrying peak loads. Hydraulic storage has been used in this country at the Rocky River hydroelectric development of the Connecticut Light and Power Company, near Milford, Conn. This installation is 79 per cent efficient; that is, for every 100 kw. consumed in pumping the water from low head to high head, 79 kw. are returned in electrical energy through the generators. When figured from potential water power at low head furnished to the turbines driving the pumps, to kilowatt output from peak-load generators, the European plants usually average about 60 per cent in efficiency. The value of such hydraulic storage in America is doubtful. Interconnection and the rapid growth of power consumption provide a need in a few years for all power that was earlier available for pumping into storage.

Another method which in recent years has become of increasing interest is the utilization of Diesel engines for peak-load capacity in conjunction with steam or hydroelectric central stations. The installation of the 10,000-kw. Diesel-engine generators at Hamburg, Germany, and of two 7500-kw. Diesel-generator sets at Hennigsdorf, near Berlin, are the largest of such plants now in operation. This type of peak-load plant has advantages for isolated locations, and particularly near the end of long feeders.

The Ruths steam accumulator affords another method of carrying peak loads. Steam can be generated with a standard boiler plant at a uniform rate during the day, and during periods of light load, excess steam is stored in a Ruths accumulator. The stored steam is utilized during peak loads in driving a special turbo-generator which operates at variable inlet pressure. This method of operation has the advantage of flexibility and is economical in fuel consumption. The most outstanding installation is the 50,000-kw. Ruths accumulator at the Charlottenburg power station of the Berlin Municipal Electricity Works. Performance data on this plant have been recently published.[4] The economics of the application of such accumulators to American practice were fully discussed in a recent paper before the A.S.M.E. by one of the authors.[5]

PROPOSED PEAK-LOAD PLANTS

The problem of station investment to carry peak loads received much attention at the World Power Conference in Berlin last summer. Sir Charles Parsons and Robert Dowson in their paper on "The Use in Power Stations of Steam Turbines Having, With Their Auxiliaries, Large Overload Capacities," discussed the possibilities of securing additional peak-load capacity from a turbo-generator by providing bypass valves in the turbine. They proposed to use standard generators provided with the usual generator air coolers supplied either with condensate or cooling water from the circulating-water supply. At the time of peak load, the generator air would also be passed through secondary coolers furnished with refrigerated brine, which at peak loads would cool the air to 41 deg. fahr. instead of to 86 deg. fahr. as is usual with the standard air coolers. This would enable the generator output to be increased about 20 per cent during peak loads. The authors estimate that the first cost of such a plant, including refrigerating equipment, would only be about 50 per cent of that to provide a peak-load plant in the usual way.

---

[1] Professor of Mechanical Engineering, Johns Hopkins University. Mem. A.S.M.E.

[2] Graduate Student, Mechanical Engineering, Johns Hopkins University. Assoc-Mem. A.S.M.E.

[3] "Der Entwicklungsstand der Speicherpumpen," by W. Hahn. *Z.V.D.I.*, June 21, 1930, p. 881.

Presented at a meeting of the Metropolitan Section of the A.S.M.E., New York, January 8, 1931.

[4] "Untersuchungen an einer 50,000 kw. Ruths Speicheranlage," W. E. Wellmann. *Z.V.D.I.*, June 7, 1930, p. 743.

[5] "The Peak-Load Problems of Steam Power Stations," A. G. Christie. Trans. A.S.M.E., vol. 51, no. 12, 1929.

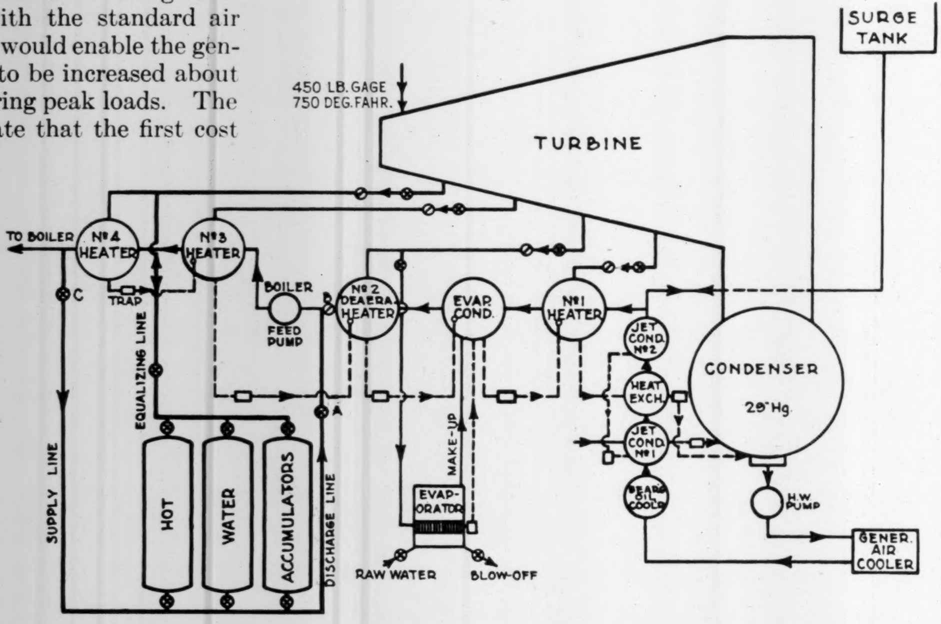


Fig. 1 Feedwater-Heating Cycle and Arrangement of Equipment—Storage After No. 4 Heater

Eric Brown, of the Brown-Boveri interests, in his paper on "The Non-Operative Turbo-Generator as an Immediately Available Power Reserve," which was also presented before the World Power Conference in June last, calls attention to the fact that it takes from 6 to 60 minutes to get a cold turbine up to operating speed when it is needed. This detracts from the ability of a power station to respond immediately to rapid changes in power demand and to emergencies. He points out that for this reason more turbo-generators are frequently maintained in operation than required by the normal power demand in order to meet these conditions, and the efficiency of the power stations suffers in consequence. Mr. Brown proposes a method for keeping the stand-by turbine heated to service temperatures and hence available for instantaneous starting when needed. This is done by placing an insulated casing a foot or so from the turbine casing, and circulating through this space air preheated to the saturated temperature of the steam or even to a higher temperature. The air is heated by suitable electric resistance heaters thermostatically controlled to provide the desired temperature. The turbine is thus maintained at operating temperature, and can be started immediately with no fear of distortions such as may occur in warming up a cold unit. This system has been tried on some commercial units in Europe. The heating requirements have been found to be equivalent to about 5 per cent of the steam required to keep the turbine at speed with no load. Such a system would make stand-by units instantly available for service, but would not decrease plant investment.

In this country, modern developments in steam power plants have led to the general acceptance of turbo-generator units of the bleeder type, in which steam is extracted at several points and utilized for heating the feedwater. High-temperature feedwater is obtained economically in this manner. At the same time the turbo-generator capacity is reduced below that possible of attainment with complete expansion without bleeding, and with the same steam flow entering the turbine. This suggests the idea that increased turbo-generator output might be obtained by shutting off the bleeder heaters and permitting the total steam flow to pass through the whole turbine to the condenser. That such power is available and can be obtained, has been demonstrated by trials made at Gould St. station, Baltimore, Long Beach station, Los Angeles, and Lakeside station, Milwaukee, where increased capacity was secured by cutting off certain of the bleeder heaters. These trials indicated that capacity for short peaks could be obtained by this method. Hence manipulation of the bleeder heaters can be considered as an additional method of providing peak-load capacity in a plant.

Certain other problems are introduced by shutting off the bleeder heaters. Colder feedwater must be supplied to the boilers, and when all heaters are cut off this feed will be at condensate temperature. This increases the heat per pound that must be supplied by the boiler, and therefore increases the rate of firing. The furnishing of cold feedwater is not good practice as it increases stresses in feed lines and in boiler shells. Rapid changes in temperature such as result from suddenly cutting off bleeder heaters and feeding cold water would be highly undesirable. However, if there is no objection to cold feedwater and to further overloading the boiler and furnace, substantial increases in peak-load capacity can be obtained by shutting off the bleeder heaters.

These considerations indicate that any method which could be developed to discontinue bleeder feedwater heating at the time of peak loads without at the same time necessitating the use of cold feedwater for boilers, deserves careful consideration as a desirable means for carrying peak loads of relatively short duration.

The diagrammatic arrangement of such plant equipment is shown in Fig. 1. A modern turbine is provided with the following auxiliaries: four bleeder heaters, one of which is a closed-tube deaerator heater; a one-stage evaporator with evaporator condenser; a heat exchanger; two jet condensers for the vacuum jet air pumps; a bearing oil cooler; and a generator air cooler. With this equipment in service the full capacity of the turbo-generator set was assumed to be approximately 62,000 kw. when operating at 450 lb. gage steam pressure, 750 deg. fahr. steam temperature, 29 in. of vacuum, with boiler feedwater heated to 386.8 deg. fahr. leaving the last bleeder heater, and when 673,000 lb. of steam per hour is entering the throttle. Hot-water accumulators, surge tanks of increased capacity and some additional valves and piping form the only equipment added to this standard layout to enable it to carry peak loads with all bleeder heaters out of service and the boilers furnished with hot feedwater from storage.

During periods of heavy load in excess of nominal maximum capacity when bleeding, the extraction of steam to the four heaters is discontinued and the condensate, after passing through the generator air cooler, bearing oil cooler, No. 1 jet condenser, the heat exchanger, and No. 2 jet condenser, is stored in the surge tank. Feedwater for the boilers at about 365 deg. fahr. is furnished from the hot-water accumulators. A small amount of steam is automatically supplied from No. 4 bleeder-heater connection to the hot-water accumulators to compensate for the displacement of the hot water drawn off by the boiler-feed pump and to maintain pressure in the accumulators. These accumulator tanks should be normally full of water and in continuous contact with, and circulated by, steam from this fourth bleeder point when heavy loads are expected. The water in the accumulators, therefore, has approximately the same temperature as the steam from No. 4 bleeder.

In order to demonstrate the simplicity and efficiency of the proposed system, assume that the accumulators are filled with hot water at the temperature of the fourth bleeder heater, and that the load with all four bleeders in operation is approaching the maximum capacity of the turbine under such conditions. The discharge valve *A* from the accumulators to the boiler-feed pump suction is opened. The water pressure in the accumulators exceeds that from the condensate pump at the inlet to the boiler-feed pump and causes the check valve *B* on the regular feed line to close automatically. The feedwater from the accumulators leaves the boiler-feed pump and passes through the third and fourth bleeder heaters at the temperature at which it normally leaves the fourth bleeder heater. Hence no steam is drawn from the turbine shell to heat the feed in these two heaters, and they therefore act as though they were cut off from the turbine. The steam normally withdrawn at these two points now passes down the turbine to the condenser, increasing substantially the available energy to do work in the turbine.

When check valve *B* closes, the flow from the condensate pump can no longer pass through the first and second bleeder heaters but passes directly to the surge tank. With no water flowing through these two heaters, no steam is withdrawn at the corresponding two bleeder points and the two heaters are virtually cut off from the turbine. The steam that would normally be bled at these two points now passes to the condenser and adds further available energy to that provided by the steam not now required in the third and fourth heaters. Thus the output of the turbine may be substantially increased with no added flow of steam at the throttle. This increase in output is substantial even after allowance is made for increased leaving losses and for decrease in condenser vacuum with the flow of cooling water maintained constant.

The simplicity of this system is emphasized by the fact that the only operation required is that of opening valve *A*. All other events are automatic in their nature. It is even possible to provide a control at valve *A* which will automatically open it when the generator load, or as an alternative, when a certain stage pressure reaches a predetermined amount.

In later periods of load below full capacity, bled steam to the four heaters is utilized to heat not only the condensate from the condenser at that load, but also a portion of the excess condensate which was stored in the surge tank during the peak-load period. This excess supply of hot water above boiler-feed requirements is utilized in charging or refilling the hot-water accumulators through valve *C*. The rate of heating this excess water is adjusted by valve *C* so that sufficient steam is bled during this charging period from the bleeder points to place an efficient load on the boiler plant, and also so that the turbine operates at approximately its most economical rating. Other charging rates could of course be utilized if necessary.

Thus, with a standard, modern installation and with the addition of a few insulated tanks, piping, and valves for hot-water storage, an enlarged surge tank, and the utilization of generator reserve capacity either provided at the time of installation or by supplementary generator air cooling if necessary, a simple method of obtaining peak-load capacity for short periods is secured with a minimum of equipment.

Plant Performance

Heat-balance calculations have been made for such a four-bleeder heater installation having a maximum output of 62,040 kw. and a most economical loading of 51,150 kw. with all bleeders in normal service, and with operating conditions of 450 lb. gage, 750 deg. fahr., and 29 in. vacuum, and 386.8 deg. fahr. feedwater temperature from heaters, at maximum load. Air preheating to 400 deg. fahr., with forced- and induced-draft fans, was assumed with powdered coal for a boiler plant consisting of three boilers, each of 23,000 sq. ft. of heating surface, operating at 84 per cent efficiency when delivering the maximum steam required. The power requirements of circulating pumps, hot-well pumps, boiler-feed pumps, coal preparation for powdered fuel, vacuum pump for deaerator, evaporator pump, transformer-oil cooling, service-water pump, forced- and induced-draft fans, and miscellaneous intermittent service were computed. The net station output at maximum capacity is 57,630 kw. and 48,200 kw. at most economical load, after allowing for all station auxiliary requirements. This net station output allowing for auxiliaries could be increased with the use of hot-water accumulators, as outlined above, from 57,630 kw. to 67,825 kw., an increase in capacity of 10,195 kw. or 17.7 per cent. Table 1 gives the various capacities and station heat rates for normal operation without accumulators, and for operation on peak loads with accumulators designed for two-hour peaks of rectangular form. The accumulator was assumed to be recharged over an eight-hour period, four times as long as that of discharge.

TABLE 1 STATION PERFORMANCE DATA

Normal Operation				
Net station output, kw	57,630	48,200	36,900	25,060
Overall station performance, B.t.u. per kw-hr	15,130	14,150	14,750	15,330
Accumulator Discharge				
Net station output, kw	67,825	61,655	57,645	55,800
Overall station performance with accumulators discharging, B.t.u. per kw-hr	12,900	12,770	12,470	12,210
Compensated station performance for accumulators discharging, B.t.u. per kw-hr	14,875	14,695	14,385	14,120

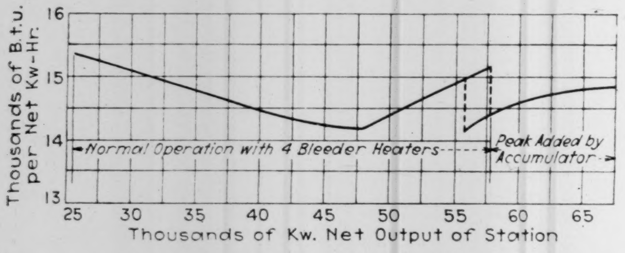


Fig. 2 Station Heat Rate

Two performance figures in B.t.u. per kw-hr. are given for accumulator discharge conditions in Table 1. The first figure represents the actual performance during the peak-load period when the boilers receive stored hot water from the accumulators. The second figure, marked "Compensated station performance for accumulators discharging, B.t.u. per kw-hr.," indicates the station rate during peak load with the accumulators discharging, but with calculated allowances included for the extra heat required from added bled steam to heat the water on its way from the surge tank to the accumulators at other times and at loads less than maximum capacity during the charging periods of the accumulators. These calculations involved the determination of the total station heat consumption under a variety of loads with and without charging of the accumulators.

The data in Table 1 are shown graphically in Fig. 2, which presents the performance curve of the station for normal operation, and for operation with the accumulators discharging on peak loads.

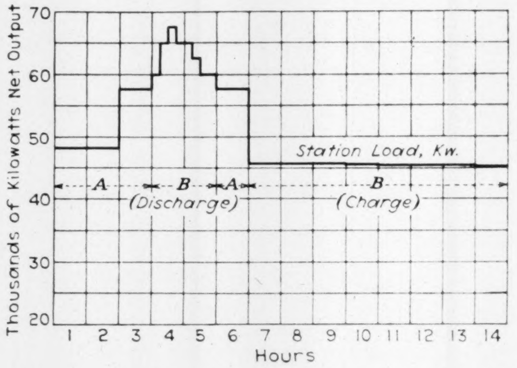


Fig. 3 Hypothetical Load Showing Effect of Accumulator Discharge and Charge

A—Normal operation.
B—Accumulator operation: Average total heat, 714,000,000 B.t.u.; average load, 50,650 kw-hr.; average heat rate, 14,470 B.t.u. per kw-hr. (compensated).

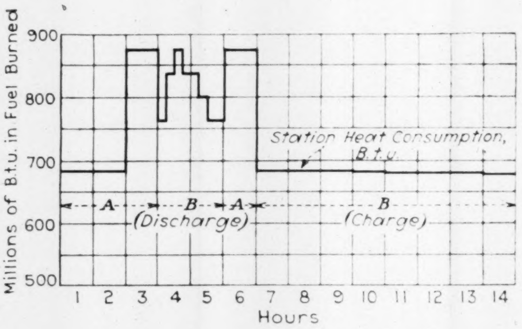


Fig. 4 Station Heat Consumption for Hypothetical Load

A—Normal operation.
B—Accumulator operation: Average total heat, 714,000,000 B.t.u.; average load, 50,650 kw-hr.; average heat rate, 14,470 B.t.u. per kw-hr. (compensated).

Fig. 3 presents a hypothetical station load curve showing the application of the accumulator during the peak load. Fig. 4 shows the gross heat consumption of the station for normal operation, with the accumulator discharging over the peak load and with subsequent charging of the accumulator at lower loads as shown in Fig. 3. The peak is variable and approximately of triangular form, as is usually the case. But the equipment is flexible, so that any variety of peak or sustained load could be handled successfully for the length of time for which the accumulators are designed. Naturally the total duration of the peak load that may be carried is governed by the storage capacity of the accumulators. For a two-hour peak three accumulators of 8480 cu. ft. capacity each have been provided for this plant. They are 12 ft. in diameter with hemispherical ends, and 80 ft. long. They are of sufficient size to store the 1,366,000 lb. of feedwater required for operation of the plant at full peak-load capacity for two hours. These accumulators were estimated for installation out-of-doors with 5 in. of insulation and with an outside sheet-metal covering. Increased surge-tank capacity of approximately 22,500 cu. ft. was assumed to be provided within the plant.

Plant Costs

To provide capacity for the 67,825-kw. peak continuously for a period of two hours for this plant, an estimated investment as shown in Table 2 would be required. These figures are believed to substantially represent actual costs.

TABLE 2 ADDED PLANT COST WITH ACCUMULATORS

Three accumulators, each of 8480 cu. ft. capacity	$110,000
Foundations for accumulators	15,000
Insulation for accumulators	10,000
Additional valves, piping, and pipe covering	15,000
Cost of enlarged surge tank	16,000
Cost of 10,000 kw. of increased generator capacity and cooling system at $5 per kw	50,000
Engineering and overhead expenses at 15 per cent	32,400
Total	$248,400

The total increase in capacity as before noted was 10,195 kw. The plant cost is $24.36 per kw. of added peak capacity, which may be compared with $90 to $100 per kw., which is the average cost of standard plant in modern stations of the size here considered.

Should a continuous, sustained peak of 67,825 kw. not be required for two hours, smaller accumulators could be used, and the investment cost would be decreased. If peak loads last longer than two hours, more or larger accumulators would be needed, at an added cost.

Capacities

This investigation reveals that a modern station having a net output of 57,630 kw. with a heat consumption of 15,130 B.t.u. per hour, could at this output carry a peak load of 67,825 kw. for two hours at a compensated heat rate at such load of approximately 14,875 B.t.u. per kw-hr., after the installation of hot-water accumulators, increased generator capacity, and the necessary piping and equipment. This addition of 10,195 kw. peak-load capacity represents an increase of 17.7 per cent in net station capacity, and can be obtained for a two-hour peak at an investment of approximately $24.36 per kw. of added capacity. The use of such equipment would be simple, flexible, and as economical as the present maximum capacity of the station, and comparable with average station performance under normal conditions.

Calculations have also been made for a plant of similar capacity and arrangement by assuming the same maximum throttle flow of steam, but with five bleeder heaters producing a final feedwater temperature of 403 deg. fahr., instead of 386.8 deg. fahr., at maximum load. With the addition of the fifth heater, 56,595 kw. net station output could be obtained as the maximum normal loading with a heat rate of 15,200 B.t.u. With the accumulator on discharge, a net station load of 68,620 kw. could be carried at the time of peak load with a compensated heat expenditure of 14,820 B.t.u. Therefore, with the fifth heater, an increase of 12,025 kw. or 21.25 per cent in net station capacity was obtained in the peak load that could be carried over that possible with a five-bleeder-heater installation without accumulator storage.

Calculations were also made to determine the per cent increase in peak-load capacity that could be obtained with a similar plant if it were provided with only three bleeder heaters. In this case, the feedwater was heated to 317.1 deg. fahr. at maximum load. With three bleeder heaters, the maximum net station output of 61,730 kw. would be obtained with a heat expenditure of 15,130 B.t.u. per kw. without accumulators. With accumulators, a net station capacity of 67,970 kw. could be obtained for peak load with a compensated heat expenditure of 15,060 B.t.u. per kw-hr. This is an increase of 6240 kw. or 10.1 per cent in the peak capacity by the use of accumulators over that to be obtained by a three-bleeder-heater installation without accumulators.

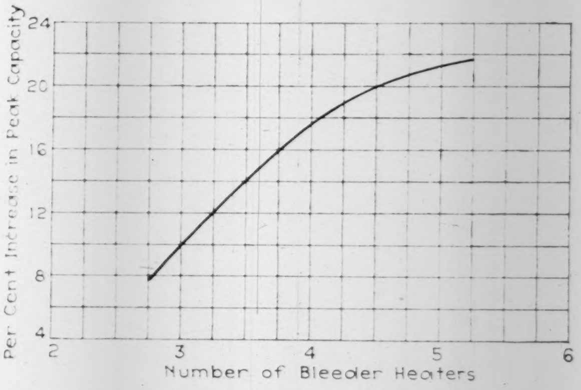


Fig. 5 Effect of Number of Bleeder Heaters on Station Peak-Load Capacity With Accumulators

It will be noted that in each case the economies of operation, which include all radiation and heat losses, are substantially as good with the accumulator as they would be without the accumulator installation after allowing for recharging the accumulator. The peak load to be obtained above the maximum capacity of the normal plant is, with the case considered, 10.1 per cent for three heaters, 17.7 per cent with four heaters, and 21.25 per cent with five heaters as shown in Fig. 5. Furthermore these gains are secured with no increase of boiler or furnace ratings over those with all bleeders in operation.

In regard to turbine design and the number of bleeder heaters to be utilized, the justification of the last heater depends upon the amount by which the fuel saving, as represented by the improved heat rate, exceeds at the given load factor the fixed and operating costs of the heater. With the utilization of hot-water storage it is probable that an additional heater may be warranted on the basis of the additional low-cost peak-load capacity that may be secured through its use. In new station designs it is quite probable that the use of five bleeder heaters in conjunction with hot-water accumulators will be employed to an increasing extent to provide such low-cost peak capacity.

OTHER SYSTEMS WITH WATER STORAGE

The scheme of hot-water storage with four bleeder heaters considered in the preceding paragraphs requires that the accumulators be built for a steam pressure of 215 lb. per sq. in. gage, to store hot water at 365 deg. fahr. The cost of accumulators may be reduced if this storage can be provided at a lower pressure. This can be done in either of two ways, provided boilers and furnaces can be overloaded beyond the capacity required with all bleeder heaters in service.

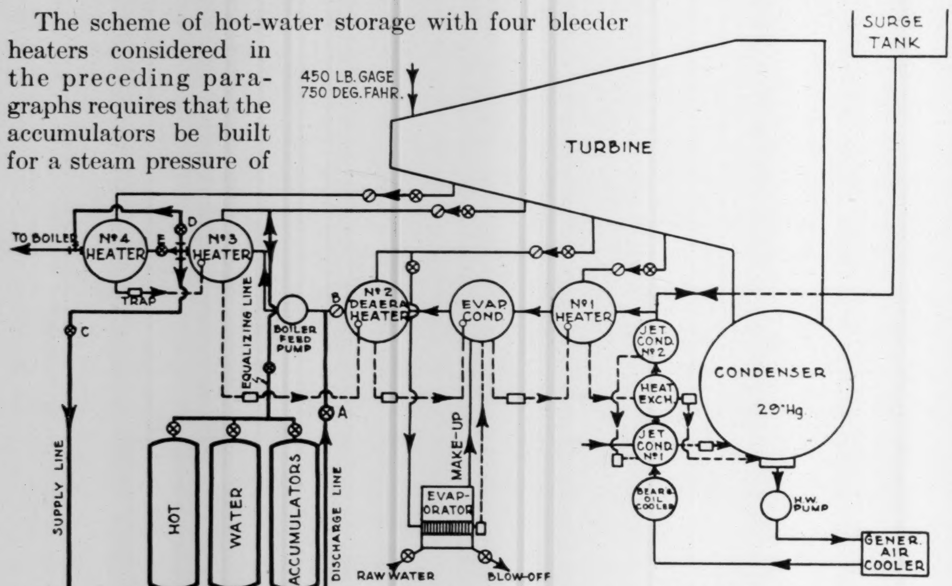

SURGE TANK
450 LB. GAGE
750 DEG. FAHR.
TURBINE
TO BOILER
No 4 HEATER
No 3 HEATER
D
E
TRAP
C
B
A
EQUALIZING LINE
BOILER FEED PUMP
No 2 DEAERA HEATER
EVAP COND
No 1 HEATER
JET COND. No 2
HEAT EXCH
JET COND. No 1
BEAR & OIL COOLER
CONDENSER
29" Hg
H.W. PUMP
GENER. AIR COOLER
SUPPLY LINE
HOT
WATER
ACCUMULATORS
DISCHARGE LINE
MAKE-UP
EVAPORATOR
RAW WATER
BLOW-OFF

FIG. 6 FEEDWATER-HEATING CYCLE AND ARRANGEMENT OF EQUIPMENT—STORAGE AFTER NO. 3 HEATER

The hot-water accumulators may be placed as shown in Fig. 6, so that they are charged with hot water which has been heated in No. 3 bleeder heater to a temperature of 299 deg. fahr. at the most efficient load. The accumulators need only be built for a steam pressure of 80 lb. per sq. in. gage, and hence will cost less than in the previous case. When the accumulators are drawn upon for peak-load service, valve *D* is opened and valve *E* closed, thus bypassing No. 4 bleeder heater. If the feed from the accumulators was allowed to pass through No. 4 bleeder heater, the normal amount of steam would be bled to heat it to 386.8 deg. fahr. at peak load, and this withdrawal of steam would seriously diminish the peak capacity of the turbine. With the arrangement shown, the net station output when the accumulators are discharging would be about 67,770 kw., an increase of 17.5 per cent over full bleeding conditions. The accumulator water will pass to the boiler at 299 deg. fahr., requiring an increase of boiler rating and of fuel burned of approximately 8.6 per cent.

The storage of hot water after No. 2 bleeder heater is possible at a still lower first cost. The arrangement shown in Fig. 7 contemplates the storage of this water as a large hot-well reserve between the second bleeder heater and the boiler-feed pump. This hot-water storage may be in the direct feed circuit of the boiler-feed pump as shown, or may be placed in parallel with the direct feed line. The water is stored at an average feed temperature at most efficient load of 232 deg. fahr. The maximum steam pressure on this tank will be 18.7 lb. per sq. in. gage. Hence comparatively light-weight receivers can be provided for this storage. This arrangement results in the lowest-cost plant of any of the accumulator schemes shown. There would also be a further saving in valves and piping. At the time of peak load, valve *G* is opened and valve *H* closed, thereby bypassing the third and fourth bleeder heaters.

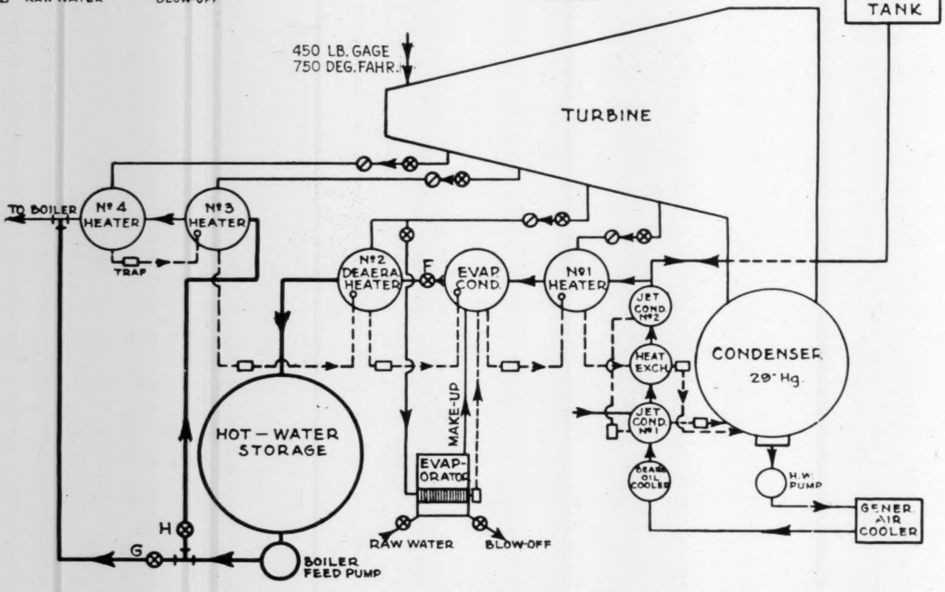

SURGE TANK
450 LB. GAGE
750 DEG. FAHR.
TURBINE
TO BOILER
No 4 HEATER
No 3 HEATER
TRAP
No 2 DEAERA HEATER
F
EVAP COND.
No 1 HEATER
JET COND. No 2
HEAT EXCH
JET COND. No 1
BEAR & OIL COOLER
CONDENSER
29" Hg
H.W. PUMP
GENER. AIR COOLER
HOT-WATER STORAGE
MAKE-UP
EVAPORATOR
RAW WATER
BLOW-OFF
H
G
BOILER FEED PUMP

FIG. 7 FEEDWATER-HEATING CYCLE AND ARRANGEMENT OF EQUIPMENT—STORAGE AFTER NO. 2 HEATER

Valve *F* is closed, thus putting the first and second bleeder heaters out of operation. Feed-pump conditions would be normal throughout, so that no change in water inlet pressures would occur as in the preceding schemes. The net station output at maximum capacity with the accumulator discharging would be about 67,670 kw., equivalent to an increase of 17.4 per cent over maximum capacity with all bleeders in service. The feedwater now passes to the boiler at about 232 deg. fahr., which would require an addition of 15.4 per cent to the boiler capacity and to the coal burned. This, however, is not a serious consideration, for if it is assumed that the boilers operate at 304 per cent of rating with full capacity of 57,630 kw. with all four bleeders in service, they will now be operated at 352 per cent of rating at maximum peak load of 67,670 kw. with water storage after No. 2 bleeder heater. Peak loads are assumed to be of short duration, and hence this increased rating of boilers is not excessive.

Considering these three schemes for using hot-water accumulators, the gain in peak-load capacity is substantially the same, i.e., 17.5 per cent, whether the accumulators are placed after No. 4, No. 3, or No. 2 bleeder heater. However, the boilers and furnaces operate at the same ratings with or without accumulators in service when placed at No. 4 bleeder heater, but at increased ratings in the other positions.

Several other schemes have been suggested to provide hot feedwater when the bleeder heaters are cut off during peak loads. One interesting suggestion is the use of diphenyl oxide. A large reservoir of diphenyl oxide would be heated by a heater in the flue gases and stored at moderate pressure. The feedwater on its way to the boiler would be heated by diphenyl oxide circulated through a feedwater heater during peak loads when bleeder heaters are shut off. No surge tank or water storage need be provided as the condensate can go direct to the boilers through the diphenyl oxide feed heater.

Systems With No Water Storage

When boilers can be operated at high ratings when fed with water colder than normal, peak-load capacity can be secured by simply cutting off the bleeder heaters. The gains already indicated in unit capacity can be secured by cutting off all four bleeder heaters and feeding the condensate directly to the boiler. Additional generator capacity must be installed or some method of secondary generator cooling, such as the refrigeration plan of Sir Charles Parsons. The latter could be easily added to a unit now in service.

A considerable gain in unit capacity may be secured by cutting off No. 4 bleeder heater only. Computations indicate that the peak-load capacity will be increased about 6 per cent by this method, while the boiler rating and fuel consumption will be increased about 7 per cent.

If both No. 4 and No. 3 bleeder heaters are cut off, the peak-load capacity will be increased about 11.8 per cent, with an increase of boiler rating of approximately 14 per cent.

Additional data on the gains in turbine capacity that may be secured by cutting off bleeder heaters are shown in Fig. 8. These curves were presented in the recent N.E.L.A. report on Turbines[6] and give data from tests on a 94,000-kw. General Electric turbo-generator with four bleeder heaters and operating with 400 lb. per sq. in. gage pressure, 725 deg. fahr., and 28.5 in. vacuum. Attention is directed to the fact that the "Per Cent Gain in Capacity" shown on these curves refers to the turbo-generator capacity only, and not to the net station output as is the case in the figures quoted above.

These methods give substantial increases in peak-load capacity at a small sacrifice in station economy. The interesting point is that their use involves no additional cost provided the generator can carry the added load. Additional cooling in the generator would not be expensive. Such methods can be used advantageously at the time of peak load in almost any modern plant with three or more bleeder heaters.

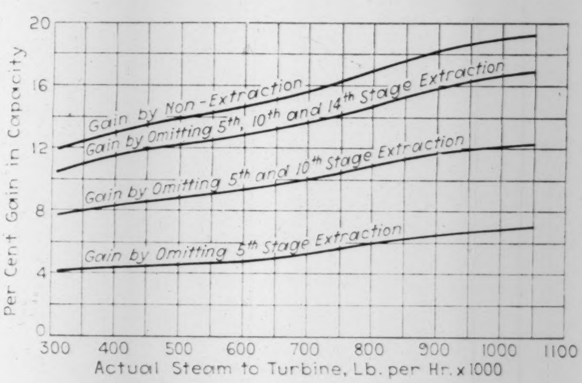


Fig. 8 94,000-Kw. General Electric Turbine, Four-Stage-Extraction Operation—Per Cent Gain in Capacity by Reducing Extraction at Operating Vacuum

Conclusions

The utilization of hot-water storage in accumulators for peak loads requires a low investment, is simple and reliable in operation, and is economical in fuel consumption. Its performance is comparable with the heat rate of a modern station with bleeder heaters of normal design at maximum output. The hot-water-accumulator method requires little special equipment, and its simplicity of operation indicates that it should meet with success in installations where peak-load capacity must be provided at minimum cost and where large boiler and furnace overloads are not desired.

Increased peak capacities may be secured in stations using bleeder turbines by simply shutting off these bleeders during peak loads, provided the boilers can take cold feedwater and can be operated at considerably increased ratings for the duration of the peak. This is probably the lowest-cost means of providing for peak loads.

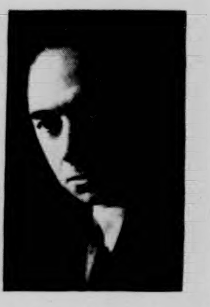
---

[6] "Turbines." Prime Movers Committee Report No. 078, National Electric Light Association, 1930.

High-Pressure and High-Temperature Steam for Locomotives

Advantages of High Pressures and Temperatures in Stationary Practice Both for Condensing and Back-Pressure Operation—Behavior of Metals and Boiler Circulation Under Extreme Conditions—Possible Lines of Development of Locomotives

By C. F. HIRSHFELD,[1] DETROIT, MICH.



LET me start this paper by making several statements having nothing to do with high steam pressures and temperatures.

First, I know practically nothing about steam locomotives in the sense in which railroad men know about them;

Second, I have great respect for the engineers who have developed the steam locomotive to its present state; and

Third, I am not presumptuous enough to believe that I can teach such men anything concerning that which they know so much about and with respect to which I know so little.

With such an introduction one might well inquire why I present this paper. To be perfectly frank, it does not result from any spontaneous ebullition of ideas insistent upon being disclosed to the world at large or to a particular group in that world. It was asked for by your Division, apparently in the belief that one familiar with modern developments in stationary steam practice might be able to bring you useful thoughts and experiences from that field. I recognize this as a possibility and, remote as it may be, it must serve as my excuse.

Some thirty-odd years ago the stationary-plant engineer began a march of progress which probably represents one of the most remarkable advances ever made in a like period. It happens that my life in the capacity of wage earner started at about the beginning of this period, and that a teaching experience of some years caused me to become familiar with the history of power-plant engineering in the preceding period.

Looking at the steam locomotive through the eyes of an engineer who has concentrated his efforts in the stationary field, I am struck by the fact that it appears to have improved little during the period in which my own field of endeavor has made such rapid progress. To be sure, it has been made bigger, superheaters have been adopted, feedwater heaters have been added, and so on, but the locomotive that I viewed with wonder as a small boy and the locomotive that I view more understandingly as a middle-aged man are essentially the same.

Basic Changes in Locomotive Design Apparently Necessary

If one may judge from the presently evident movements in the field, the economic conditions have altered to such an extent that basic changes in locomotive design are felt to be necessary. If this be the case, designers will have to bestir themselves and acquire a new point of view. No longer will it be sufficient to improve by whittling here and adding there. It will be necessary to consider the whole problem *de novo*, to depart temporarily from all the traditions of the past, to let the imagination have free rein in team with analytical ability. What will evolve may possibly be guessed at; it certainly cannot be predicted.

It is natural that in considering any radical change from past practice, designers should give thought to what has happened in more or less parallel fields, as, for instance, in that of the stationary power plant. Such developments may or may not be applicable to the plant required to move about as does a locomotive, but the facts cannot be determined except by analysis, and possibly also by experiment.

When the locomotive designer begins to study recent stationary-plant development he discovers marked increases of steam pressure during a comparatively short period, and latterly a very evident tendency toward radical increases of steam temperature. It is but natural to ask whether these are proper items for serious consideration in his field of endeavor.

In stationary practice there are two radically different conditions leading to the use of high steam pressure. The first is the higher thermal economy obtainable in condensing plant. The second is the greater quantity of power obtainable from steam expanded in an engine or turbine and then exhausted, at pressures near or above atmospheric, for process or heating

---

[1] Chief, Research Department, The Detroit Edison Company. Mem. A.S.M.E. Mr. Hirshfeld received the degree of B.S. from the University of California and his Master's degree in Mechanical Engineering from Cornell University. Until 1913 he served as a member of the faculty of the latter institution, then becoming associated with The Detroit Edison Co. He has continued his consulting practice in the electric light and power industry. During the War he was granted a leave of absence to serve in the Ordnance Department of the Army, being commissioned major and advancing to the rank of lieutenant-colonel.

Contributed by the Railroad Division and presented at the Annual Meeting, New York, N. Y., Dec. 1 to 5, 1930, of The American Society of Mechanical Engineers. Abridged.

purposes. Such reasons have underlain an increase of average steam pressure from about 180 lb. gage in 1900, through 200 lb. gage about 1913, to about 450 to 500 lb. gage today, with increases to 1400 and 1800 lb. in a few exceptional cases. The average steam pressure in representative locomotives is today about 220 lb. gage, with a pressure of about 280 lb. as the highest normal value. Higher pressures are in use, but may still be regarded as more or less experimental. The figure of 280 corresponds to the value reached in stationary practice in exceptional cases about fifteen years ago, and in very common use about eight to ten years ago. I can still remember very vividly the shaking of heads that accompanied the first increases above that value.

Belief That Thermal Economy Increases Indefinitely With Increasing Steam Pressure Erroneous

There is a popular belief that thermal economy increases indefinitely with increasing steam pressure, and this belief has been responsible for quite a bit of loose thinking. Comparatively simple calculations suffice to show that it is erroneous.

Inspection of Figs. 1 and 2 indicates that at 700 deg. fahr. there is probably little justification in exceeding about 600 lb. without regenerative heating and something like 800 to 900 lb. with four-stage regeneration, unless reheating be resorted to. In practice the limits are set in both cases close to 500 lb. because of the serious effect of condensate in the steam. The situation is naturally improved by increasing the initial temperature. If 1000-deg. fahr. steam could be used, the practical or commercial upper pressure limit without reheating would probably be in the neighborhood of 1000 lb.

The Question of Condensing Operation

The question of whether condensing operation is possible or desirable with steam locomotives appears to be unanswered as yet. If the experiments that are now being made with condensing turbine-driven locomotives should prove such construction to be commercially feasible, the figures just given may serve to indicate the extent to which steam pressure may be profitably carried when viewed with respect to thermal considerations only.

There are, however, other considerations which may also be weighty, particularly in the case of locomotives. Thus, for example, high-pressure steam occupies much less space per unit of weight than does saturated steam. One pound of steam at 200 lb. absolute and 700 deg. fahr. occupies a space of 3.4 cu. ft., whereas the same weight at the same temperature, but at a pressure of 1400 lb., occupies only 0.4 cu. ft. As a result of this fact, pipes and other parts for high-pressure steam may in fact weigh less than for the equivalent amount of low-pressure steam. Many peculiar effects follow from this and other characteristics of high-pressure steam, and it is almost certain that the thermal savings will not be completely determinative.

When non-condensing operation is considered we obtain an entirely different sort of picture from that disclosed above. I shall present it as it appears when considered with respect to industrial plants in which steam is exhausted for process purposes. You who are more familiar than I with the locomotive engine can translate my figures easily to the terms in which you deal.

Certain numerical values for this condition and others obtained therefrom are shown in Figs. 3–6. These values are developed for steam-turbine plant. In reciprocating plant running under conditions of greatest economy the values would probably lie between those shown and others shown in the complete paper for 20,000-kw. units.

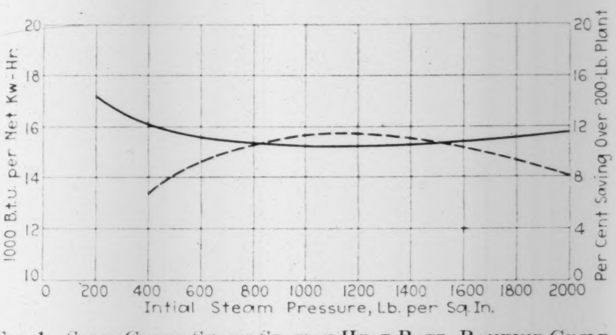


Fig. 1 Solid Curve Shows Station Heat Rate, Rankine Cycle, No Regenerative Feed Heating, Steam at 700 Deg. Fahr. Broken Curve Shows Per Cent Saving Over 200-Lb. Plant

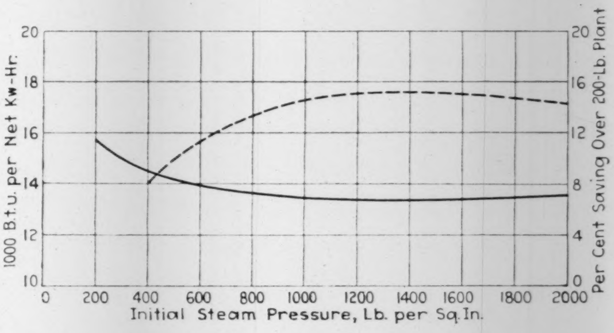


Fig. 2 Solid Curve Shows Heat Rate With Four Stages of Regenerative Feed Heating and Steam at 700 Deg. Fahr. Broken Curve Shows Per Cent Saving Over 200-Lb. Plant

Inspection of Fig. 3 shows the same sort of reversal in the 700-deg. fahr. curve that was noted for condensing conditions. With the highest initial temperature a continuous improvement is shown with increasing pressure. The really significant figures for non-condensing operation are those plotted in Figs. 4 and 5, giving the net output per 1000 lb. of steam expanded down to 5 lb. gage pressure. Even at the low initial temperature of 700 deg. fahr., Fig. 4, an increase of output of over 20 per cent is obtained from a given weight of steam by raising the initial pressure from 200 lb. to 400 lb. It is particularly interesting to note the comparatively small gains resulting from increasing the initial pressure above 800 lb., even at comparatively high initial temperatures.

Decrease in Engine Size With Increase of Pressure

The curves given in Fig. 6 probably put this matter in somewhat more significant fashion for the locomotive designer. These curves show the decrease in "engine size" with increase of pressure. In this case this means area through the last set of blades and volume of exhaust casing. In the case of a reciprocating engine it would correspond roughly to piston displacement under conditions of minimum cut-off. It will be noted that the decreases in engine size are really significant, and it should be remembered that similar or greater decreases occur in all steam-carrying parts. It will also be noted that the greater part of the decrease is attained in most cases by the time a pressure of 600 to 800 lb. is reached.

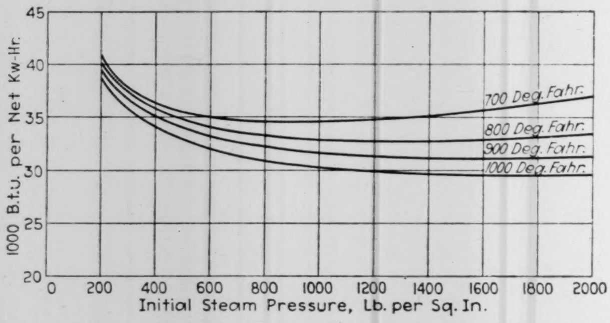


Fig. 3 Station Heat Rates for Various Initial Steam Pressures and Temperatures. 5 Lb. per Sq. In. Back Pressure. Feedwater Heated to 212 Deg. Fahr. Small Turbine Plant (2000-Kw. Units)

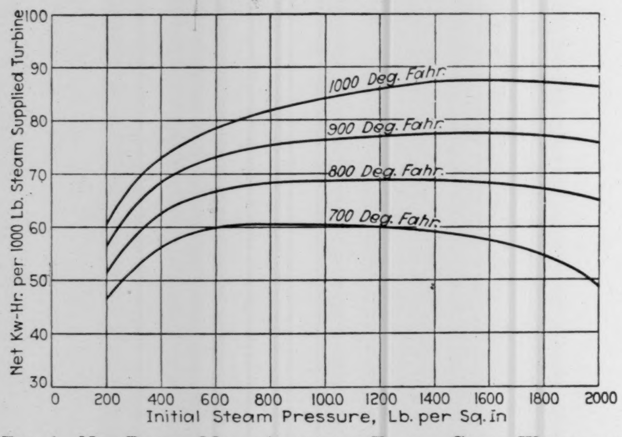


Fig. 4 Net Power Made Available From a Given Weight of Steam at Various Initial Conditions and 5 Lb. per Sq. In. Back Pressure. Feedwater Heated to 212 Deg. Fahr. Large Turbine Plant (20,000-Kw. Units)

It is at least conceivable that the combination of decreased fuel consumption per unit of output and the decreased volume might be used in locomotive practice in either one of two ways. One would be the increase of capacity without increase of grate area or its equivalent; the other would be decreased size of parts for present output. It would take much more technical knowledge of the field than I possess to evaluate the significance of such possibilities. I shall have accomplished my end if I have shown you that, even in such simple matters as thermal performance and output per pound of steam, the situation is highly complicated and requires detailed study; that it is quite erroneous to assume that improvement in these respects must necessarily follow increase of steam pressure or temperature.

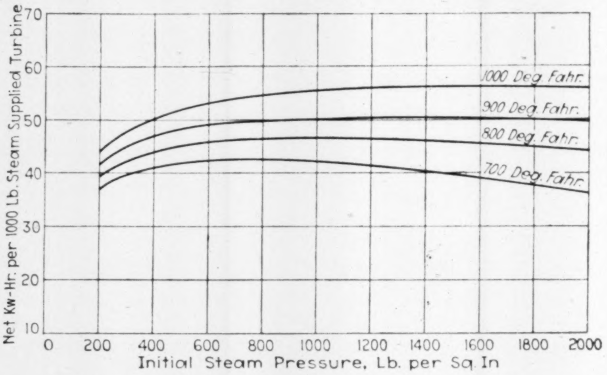


Fig. 5 Net Power Made Available From a Given Weight of Steam at Various Initial Conditions and 5 Lb. per Sq. In. Back Pressure. Feedwater Heated to 212 Deg. Fahr. Small Turbine Plant (2000-Kw. Units)

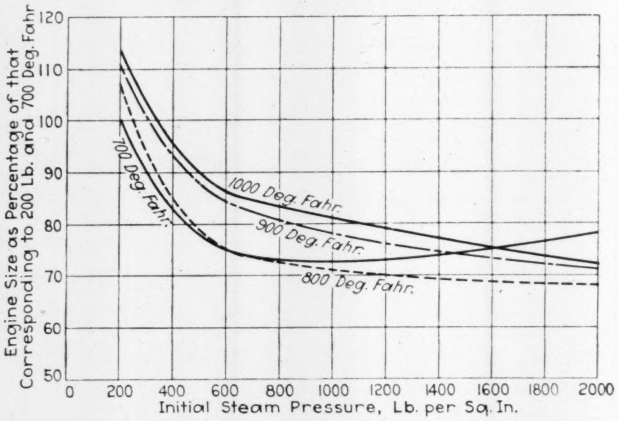


Fig. 6 Effect of Initial Steam Conditions on Physical Size of Engine. Small Turbine Plant. 5 Lb. per Sq. In. Back Pressure

It should be helpful to consider what may be expected if theoretical considerations along such lines as are suggested above should show that radical increases of pressure and temperature promise worth-while results in locomotive practice. Enough has been said to indicate that initial temperature is very closely bound up with initial pressure in turbine practice. The same thing is true to some extent in reciprocating-engine practice, even in non-condensing operation. Therefore the consideration of permissible initial temperature appears to be the logical starting point.

Temperature Limitations Imposed by Metals Available

Experience with steam superheated above a temperature of 750 deg. fahr. is still too meager to make it safe to draw final conclusions with respect to higher temperatures. Our information would seem to indicate that we are limited to steam temperatures of the order of 800 to 850 deg. fahr. if restricted to carbon-steel tubing; and that we can probably extend this temperature to 1000 or 1100 deg. if the cost of the more expensive alloy steels, which show higher creep strengths than the carbon steels, can be justified. These figures immediately enable us to determine the highest steam pressures that show thermal advantages under any selected set of conditions. It must be realized, however, that the thermal considerations alone are not completely determinative. There are many others of operating and economic character which are equally important, and much more difficult to evaluate with respect to any particular field.

Boiler Characteristics at High Pressures

If one choose about 800 deg. fahr. as the highest temperature which now seems reasonably possible under locomotive conditions, it would appear from thermal considerations as though a pressure in the neighborhood of about 800 lb. might be usable for noncondensing operation. It becomes pertinent to inquire into boiler characteristics at such pressures. Stationary experience with the higher pressures has been had with water-tube boilers exclusively, and with comparatively clean and pure boiler water. It is a far cry from such conditions to those found in average locomotive practice.

With properly designed water-tube boilers there has been no evidence of any intrinsic limitations to adequate natural circulation at pressures in the neighborhood of 600 to 700 lb., and there is no reason to expect such trouble at 800 lb. On the other hand, when pressures of 1200 to 1400 lb. are reached, the forces causing natural circulation appear to be approaching such magnitudes that very small changes of design or condition may lead to serious trouble.

In this country we have succeeded in obtaining commercially satisfactory operation at such pressures with water-tube boilers of what one may call conventional design, but it has required careful design and careful operation. European engineers, on the other hand, calculated in advance the forces that should be available for creating natural circulation, and concluded that somewhere in the neighborhood of 1200 to 1400 lb. one entered the questionable region. It is possible that this is responsible for some or all of the radically new types of high-pressure steam-producing equipment now being experimented with in Europe.

Speaking first in general terms, the temperature of saturated steam rises with its pressure. Thus, even though the metal surfaces be scrupulously clean on the water side and even though we assume the same thickness of metal in all cases, the average temperature of the boiler metal increases as the pressure under which steam is generated increases. It is also true that with similar structures the metal thickness would increase with pressure, so that at a given rate of heat transfer its average temperature would also increase slightly because of the slightly greater temperature drop through the metal. It is also obvious that an increasing rate of heat transfer through the metal must correspond to an increasing temperature drop through that metal and thus to a higher average metal temperature.

In stationary practice and with clean water no limit to increase of pressure has yet been set by such phenomena. However, two things of interest have been uncovered. An almost unbelievably small amount of scale on the water side in 1200- to 1400-lb.-pressure boilers is fatal to those surfaces subjected to high rates of heat transfer. And it is possible to show by calculation that with heat-transfer rates which may be regarded as possible of achievement, the metal of exposed tubes in a 1400-lb.-pressure boiler may reach temperatures at which the existing stresses will cause fairly rapid creep.

If one may judge from such meager evidence, it would seem that even if the locomotive boiler were modified structurally so as to adapt it to use with pressure of this order of magnitude, the feedwater conditions now characteristic of locomotive practice would make operation at such pressures impossible. In fact, I greatly doubt whether operation at a pressure as low as 400 lb. could be conducted commercially without great improvement over present feedwater practice as it exists throughout the country.

Feedwater Problem One of the Most Important

Looking at this field from the outside, I am impressed with the feedwater problem as one of the important ones that must be solved before any great advance of pressure can be contemplated safely. The situation of the railroads in this respect appears to me to be similar to that of the stationary plant of the better sort only a comparatively short time ago. It is only seventeen years since the first equipment for supplying distilled make-up in condensing stationary plants was installed, and even now we are only beginning to understand the treatments required in cases in which we cannot return an adequate supply of condensate. I confess that I do not know just how the problem should be handled in railroad practice, but I am convinced that some better solution than that now in hand must be found before great increases in steam pressure can be safely contemplated for general use. It may be possible that the savings of various sorts that may be made through the use of higher pressures will be found sufficient to justify large, well-distributed feedwater-treatment plants, with transportation of treated water to various intermediate supply points. Or it may be that sufficiently skilful chemists can develop more perfect and simplified treatments which can be applied on the individual locomotive with such talent as is available in its operating crew. Or it may be that condensing operation will be found feasible, even though condensation be conducted at or near atmospheric pressure. I leave such considerations to those sufficiently skilled in the economics of railroading. But I do feel that the crux of the problem lies right in this factor, and that solution calls for radical thinking, for a deliberate reorientation and a new attack upon the problem.

I am also convinced in my own mind, possibly because of my ignorance with respect to the details of the problem, that the present type of locomotive boiler must pass out if much higher pressures are to be used with the maximum of economic results. Much as I admire the peculiar fitness of the present type, I cannot but feel that it represents one of those things which, surviving through its peculiar fitness, has served to limit the possibilities of improvement of major character. We have been through this thing in the stationary field and in the marine field, and it is possibly only natural to assume that we may expect a parallel development in the railway field.

Possible Lines of Locomotive Development Utilizing High Pressures and Temperatures

I have even been so bold on occasion as to endeavor to picture just what sort of boiler I would design for a high-pressure locomotive if that problem were put up to me. That it must have a water-cooled firebox is almost self-evident. That the water-cooled surfaces should take the form of tubes for high pressure instead of plates is almost equally obvious. I suspect also that the conditions of use are such that a large reservoir of steaming ability must be available in some form. Beyond these rather rudimentary specifications one would appear to have a very clear field, provided always that the problem of a satisfactory feedwater supply can be solved.

Such thought as I have given to the matter always brings me back to substantially the same picture, which I give you for what it may be worth. I conceive first of a rather large reservoir which shall be adapted to hold a volume of water substantially at boiler temperature and which shall serve as a source of steam supply to meet sudden short-time demands. Associated with this reservoir is a system of water tubes serving as a water-tube boiler. These form the firebox, and besides give such added surface as is required to reduce the products of combustion to an acceptable temperature. Circulation through these tubes is produced by a pump which draws from the hot-water reservoir, and the tubular surface is so arranged as to discharge to that reservoir. The water tubes simply serve as a collection of heating paths starting at the pump discharge and ending at the pump suction, i.e., the reservoir from which the pump draws. Steam made is tapped off this heating system as required. I imagine that the pump speed will be regulated with respect to steam demand so that it will always circulate a large excess of water.

This may appear to you to represent very radical thinking. In one sense it is. In another, it represents a fairly logical mental extension of the path that we have followed in stationary practice. Whether it has any merit other than that of provoking comment and thus the exercise of the imagination, I know not. I do know that the imaginable solutions of the problem are so numerous that it is almost a foregone conclusion that our present one is not in all respects the best one, particularly when one considers its age and the air of assured respectability that age has conferred upon it.

One familiar with locomotive design will undoubtedly view with alarm the steam temperatures that have been suggested as desirable with higher pressures. Even a temperature of 800 to 850 deg. fahr. is not a pleasant thought in connection with locomotive engines of present design. But, once more, assuming that we retain the reciprocating engine, is the present design a necessary result? I think not.

It is almost certain that some type of poppet-valve mechanism will have to be substituted for the present types in which metal slides on metal. But I cannot see that this necessarily offers insurmountable difficulties. Cylinder lubrication, as we now understand it, will also have to be abandoned. It is at least possible to conceive a design of piston reciprocating in a cylinder which does away with actual metallic contact between these parts, and thus with the necessity for cylinder lubrication of any sort. Guiding and support of the piston would then have to be taken care of externally, and two packings would be required. Incidentally, packing against steam at high pressure and at a temperature of 800 deg. fahr. is no mean problem, but even here promising solutions are now imaginable.

If we cut loose from present designs and adopt the condensing-turbine solution, many of these problems disappear but others of equal or greater magnitude make their appearance. However, they do not seem to me in my ignorance to be more difficult than many that have been solved successfully in other fields in recent years by the simple method of breaking completely from the conventional and considering all possibilities without too great reference to past convictions.

It seems necessary to call attention to one other feature of high-pressure plant that has not been touched on. The values given in several of the figures were calculated on the basis of a constant boiler-plant efficiency. This involved an assumption which is important in the present consideration. This assumption was that the tendency of the temperature of the flue gases discharged from the boiler to rise with increase of steam pressure, due to the increased saturation temperature, was balanced by the proper addition of heat-absorbing surface of some form. A similar problem will develop in locomotive practice if very high pressures are resorted to. It may be that the economics of the situation will prove to be such that a net gain may result from the use of higher steam pressure in spite of a greater loss to the stack. On the other hand, it may prove necessary to install auxiliary heat-absorbing equipment, such as economizers or air preheaters. The facts can be determined only by a most detailed analysis and possibly by later experiment.

Spectroscopic Apparatus in Industry

Increasing Use of Spectroscope and Spectrograph in the Rapid Detection and Determination of Minute Quantities of Impurities and Other Minor Constituents That Often Affect Profoundly the Physical Properties of Materials

By CHARLES C. NITCHIE,[1] ROCHESTER, N. Y.

THE spectroscope and its more generally useful modification, the spectrograph, are instruments upon which industry has but recently begun to call for information bearing on the composition and properties of its materials. Although the spectroscope was recognized for many years as a marvelously sensitive means for detecting the presence of mere traces of various chemical elements, its use was long confined almost entirely to the fields of pure science, with only occasional and rather haphazard incursions into those of engineering. The metallurgist and the manufacturer, even the laboratory technicians in industrial plants, have been a little skeptical of the practical usefulness of these instruments, which, if considered at all, were looked on as rather mysterious, highly theoretical devices.

In recent years this attitude has been rapidly disappearing. The need for more and more minute and accurate knowledge of the composition and properties of materials has opened the industrial field to many instruments even more sensitive and based on more deeply theoretical principles than were those of the pure scientist of a few years ago. Among these are the spectroscope and spectrograph. Their particular field is the detection and quantitative estimation of those minute amounts of minor constituents—sometimes impurities, sometimes intentional and necessary additions—which often play so important a part in determining the properties of materials.

Physical Principles

The underlying principle upon which this use is based is the fact that every chemical element, if heated to a high enough temperature so that it is partially or completely vaporized and the vapor brought to a condition of incandescence, emits light which is composed of a number of discrete wave lengths definitely characteristic of that element. Every student of chemistry is acquainted with this phenomenon, which is shown by the familiar flame tests for sodium, potassium, lithium, etc. From some elements the emitted light contains but a few individual wave lengths, as in the case of the alkalis mentioned. From others, including iron, tungsten, and cobalt, it contains an enormous number, running into the thousands. In every case, however, these wave lengths are perfectly definite and unchangeable, no matter what the source or state of combination of the element. Furthermore it takes but a minute quantity of any element to give a detectable amount of its characteristic radiation. This is the reason why spectral methods will often detect amounts so small that even the most refined of chemical methods fail to reveal their presence.

The amounts which may be detected depend on a number of factors. Different elements vary greatly in the amount needed to give detectable radiation. Magnesium, copper, silver, and others are so readily detected that one-millionth of one per cent can be surely identified. Lead to the extent of one ten-thousandth of one per cent in metallic zinc gives a definite and unmistakable line in the spectrum. Bismuth, antimony, tin, titanium, and beryllium are all susceptible of detection at as low—and some of them at even lower—concentrations. In many cases it is impossible to judge with certainty because of the impossibility of finding methods whereby this limit may be checked.

A second factor is the nature of the sample, while a third is the particular technique employed in making the observations, including the size and type of the instruments.

The Apparatus

The spectrograph (Fig. 1) is essentially a photographic camera, so arranged and focused as to take, simultaneously, on a sensitive plate, a group of images or pictures of a narrow slit through which the light to be examined is admitted to the instrument. This light passes through a system of lenses and a prism (Fig. 2), whereby the individual wave lengths are sorted out and a separate image produced by each of the component wave lengths. Since short-wave light is bent by the prism more than that of longer wave length, these images are spread out or dispersed into a band

---

[1] Bausch & Lomb Optical Co. Mr. Nitchie was born in Evanston, Ill., in 1881. After attending the Evanston public schools, he went to Cornell University, where he followed the course in chemistry, being graduated in 1905. He then entered the employ of the Mineral Point Zinc Co., the midwestern subsidiary of The New Jersey Zinc Co. He continued with that and the parent company until September, 1930, when he joined the staff of the Bausch & Lomb Optical Co. In his later years with the Research Division of The New Jersey Zinc Co., he did extensive work in the application of special physical methods, including spectrography and X-ray diffraction, to the study of the composition and properties of metals, alloys, and other technical materials.

Contributed by the Machine Shop Practice Division and presented at the Annual Meeting, New York, N. Y., Dec. 1 to 5, 1930, of The American Society of Mechanical Engineers.

with the slit images, or lines, perpendicular to the direction of dispersion (Fig. 3). The positions of these lines in the spectrum are definitely related to their wave lengths, so that a simple measurement of the position suffices, after proper calibration, to reveal the wave length of any given line, after which reference to standard tables then tells what particular element was its source.

The spectroscope differs from the spectrograph only in the fact that with it the spectrum is observed visually instead of by photography. Its usefulness in analysis is necessarily limited because the eye cannot see all the lines that can be recorded on the plate. Some are too weak to make a visual impression, yet strong enough to affect the plate, which is cumulative in its reception of impressions. Others are of too long or too short wave lengths to be seen. Particularly important is the region of the ultra-violet, to which the eye is insensitive, but which is readily recorded by photography. This is the region of shorter wave lengths. In it are found many spectrum lines of the utmost importance, which must be available for observation if the fullest possible use is to be made of spectral methods. For these reasons the spectrograph is a much more versatile instrument than the spectroscope, especially when its optical parts, lenses and prisms, are made of quartz. This material is transparent to much shorter wave lengths than is glass, so that the field of the quartz spectrograph extends to wave lengths more than a complete octave below that of the visual instruments.

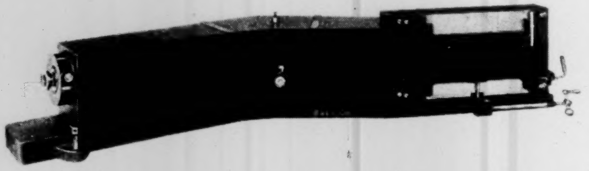


Fig. 1 A Quartz Spectrograph

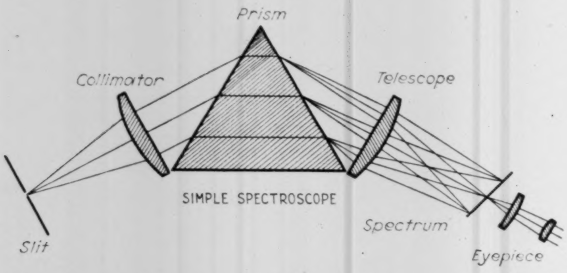


Fig. 2 Optical System of a Spectroscope or Spectrograph

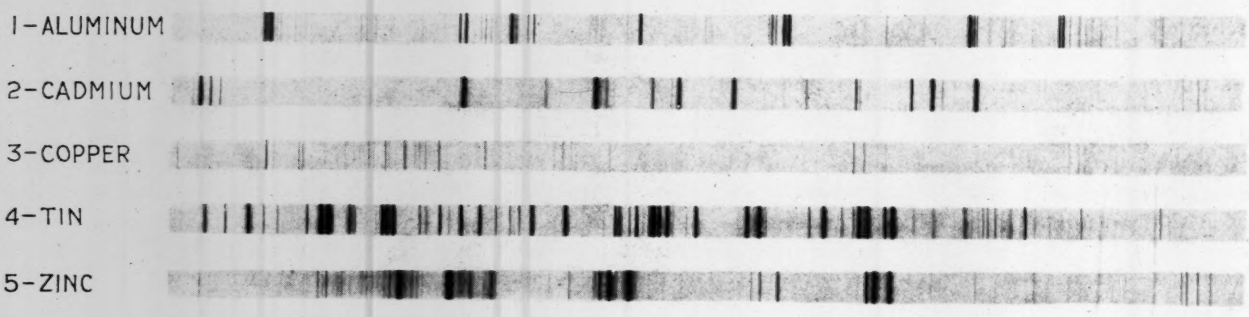


Fig. 3 Spectra of Various Metals

Methods of Observation

For exciting the radiation, several devices are used, the selection for a given purpose depending on the chemical and physical nature of the material to be examined. Sometimes a simple bunsen burner is all that is needed, the material being introduced in a variety of ways. A drop of solution on a platinum wire, a fragment of a mineral held in the flame, or a mist or spray of a solution from some type of atomizer introduced into the gas or air supply, are all methods that have been used.

Most materials require higher temperatures than are possible with the bunsen burner. Some authorities recommend the use of the oxyhydrogen or oxyacetylene burners, but a large majority of spectrographers rely mainly on the electric arc or the high-tension spark. These are passed between electrodes, either formed from the sample material, if that is electrically conducting, or from carbon or some pure metal to the end of which a small amount of the sample material has been added, either as powder or in solution.

The light from this source is focused on the spectrograph slit by a lens, and the resulting spectrum is photographed by ordinary methods.

Qualitative Analysis

When only a qualitative analysis is required, a careful measurement of the positions of the lines on the plate, together with an accurately prepared calibration curve, serves to indicate the wave lengths of the corresponding radiations and thus the identities of the various constituent elements.

Fig. 4 is part of a plate taken in the course of a typical qualitative analysis of two samples of zinc. It contains four spectra, the upper one being that of the graphite electrodes used in the arc. The second is that of a sample of exceptionally pure zinc, showing only a single impurity line, an exceedingly faint one, of lead. The third is a spectrum of a good commercial grade of slab zinc, containing as impurities iron, lead, copper, cadmium, tin, gallium, and germanium. Lines of all these elements are visible in this portion of the spectrum. The fourth spectrum is that of iron, which serves as a measuring scale for the determination of wave lengths and the identification of the lines in the other spectra.

The value of such an instrument for shop use would lie, to a large extent, in its ability to yield complete qualitative analyses in a minimum of time. Stocks of materials sometimes become mixed. Different steels with radically different compositions and physical properties look much alike to the eye. An alloy suitable for one purpose may be indistinguishable by ordinary inspection methods from one which cannot possibly serve. In all such cases spectral analysis can with speed and certainty indicate what the different materials are.

The classification of scrap metals is another use for which these instruments are well adapted. For such a purpose the individual pieces of scrap may be used as electrodes. Suitable holders may readily be devised whereby they can be brought before the instrument and their spectra observed. Alloy-steel scrap brings much higher prices than ordinary grades, and full advantage may be taken of this if the purchaser is assured that a given lot of material contains but one kind.

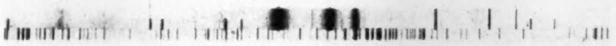


Fig. 4 A Qualitative Spectral Analysis

Die-casting alloys are of many kinds, and made from many different raw materials. Some are good, others not so good. Many are seriously injured by slight contamination by certain impurities which may be picked up from melting pots previously used for other alloys. The quickest and surest method of testing is by means of the spectrograph. Even quicker is the spectroscope, provided the material is of a composition that makes visual observation reliable.

Quantitative Analysis

Often it is not enough to know what is in a material. The engineer must know how much, in order that he may judge its quality. Here again the spectrograph comes to his aid with a speed, certainty, and precision that cannot be matched by any other method for the analysis of extremely small amounts.

For quantitative analysis, the spectra must be photographed under rigorously controlled conditions, after which the intensities of the lines on the plate are reliable indications of the amounts of the corresponding elements. Fig. 5 illustrates the principle of this method. It contains the spectra of a series of samples of a zinc alloy, each containing lead, cadmium, and magnesium as impurities. The concentration of each with respect to all these constituents is one-half that of the preceding one. The gradual decrease in the intensities of the impurities lines with decreasing concentration is readily apparent. This application is relatively new, but intensive research during the last few years has developed reliable methods which are finding wider and wider use in the industrial field. One concern is controlling the commercial manufacture of alloys in this way. Another is inspecting material purchased on specifications, with standardized limit samples whose spectra are photographed adjacent to those of the incoming material. If a maximum is set by the specifications for a certain constituent, it is then only necessary to see that the spectrum lines of that element are no stronger in the sample spectrum than in the adjacent spectrum of the limit sample.

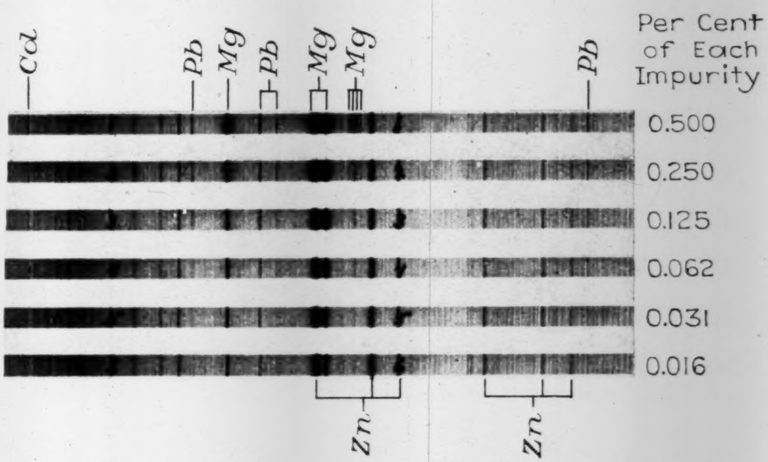


Fig. 5 A Series of Samples of Zinc Showing Decreasing Intensity of Impurity Lines With Decreasing Amount of Impurity

Materials of the same kind but from different sources sometimes behave differently in use. Such differences are almost always due to slight variations in composition which are easily detected with the spectrograph. Certain minor impurities are sometimes characteristic of the ores from a given mine or district. This fact makes it possible to tell from what source a metal originally came. The ability to differentiate in this way has at times aided in the solution of complaint cases in which the question arose whether the material involved was received from one or another producer.

Modern instruments have been so simplified and are so substantially and accurately built that they are well suited to hard, continuous work. Furthermore they can be operated by men of average intelligence with a reasonable amount of manipulative skill, and with but a minimum of attention from the technical scientists of an organization.

The industrial application of spectroscopy is yet in its infancy. A few concerns are making extensive use of it; others are employing it in a limited way. All who are making a serious effort to get the most out of it are finding new uses and new ways in which they are aided by its sensitiveness and rapidity. The certainty with which the constituents of materials can be identified, and the assurance that none will be overlooked, whether its presence was anticipated or not, are among its outstanding advantages.

With the improvements in instruments and technique that have been brought about in recent years, the laboratory that attempts to get along without spectroscopic apparatus will soon be at a serious disadvantage.

SHORTCOMINGS OF THE SPECTROSCOPE[2]

Mr. Nitchie's paper, irrespective of conciseness, points out very ably the usefulness of spectral analytical methods. For the purpose of corroboration the writer will state that he is aware of numerous cases where the spectroscope has been of great help in solving problems of a practical nature. These problems were concerned with a variety of things: metals, common and rare, heavy chemicals, reagents, minerals, ores, flue dusts, smelter wastes, slags, soils, fertilizers, biological products, glass, enamel, paint, pigments, dyes, "caroting" preparations used in manufacturing felt hats, fluorescent screens, photosensitive cells, tanning preparations, dry milk, and inorganic catalysts. But it should be borne in mind that the spectroscope has also its shortcomings. Some chemical elements, especially when present in small quantities, cannot be detected by it. Take the case of sulphur: no ordinary spectrographic method will reveal traces of this element contained, say, in blister copper. The same will apply to oxygen, chlorine, and few other elements. However, the advantages of spectral analysis by far outweigh its shortcomings.

LABORATORY USES OF THE SPECTROSCOPE[3]

Those only slightly familiar with spectroscopy usually think of the spectroscope as an instrument that is extremely useful for detecting, as our old chemistry and physics books state, one three-millionth of a milligram of sodium or one one-hundred thousandth of a milligram of lithium. Very few realize that this instrument has innumerable commercial and semi-commercial uses, and it may therefore be helpful to mention just a few of the ways in which this instrument is used in the Bell Telephone Laboratories.

1 The spectroscope is used to aid the chemical analyst doing quantitative work. A spectrogram will readily show what elements must be determined, thus guiding the analyst in selecting his method, quantities of reagents, etc.

2 It is used to identify unknown materials. Samples of materials bearing queer names such as "dubium" and "miraculum" are continually being received from inventors who are sure that these substances have certain remarkable properties on which they hope to capitalize. Without undue exertion or expense a spectrogram will usually tell quickly if the material is something new or simply an old model newly labeled. Then again, alloys of different composition but similar in appearance are occasionally mixed in stockrooms. These are readily identified by means of spectrographic analysis.

3 The spectroscope is used for chemical analysis, instead of ordinary methods, whenever the samples must not be harmed or destroyed. In these instances the material being analyzed is used as one of the electrodes, and very little harm is done to it if proper care is exercised during the sparking procedure.

4 The spectroscope is used for both qualitative and quantitative work when the samples available for analysis are too small for standard wet methods. For example, metallic films only a few molecules thick sometimes form on the walls of vacuum tubes, and occasionally it is necessary to identify them. Gases in vacuum tubes are also readily identified by this procedure.

5 The spectroscope is also used advantageously for many chemical analyses that are difficult or laborious by standard wet methods.

Many other examples could be cited, but probably nothing would be more pertinent as a recommendation for the use of the spectroscope in industry than the fact that the instrument in the Bell Telephone Laboratories is in constant daily use.

A word concerning the choice of equipment for different types of spectroscopic work might be helpful. If the instrument is to be used solely for routine testing of one or two elements that give spectra consisting of a few lines, well separated, then a low-dispersion one will be satisfactory. However, if the instrument is to be used for all types of work, it should be one that gives the highest possible dispersion. The detection of traces of impurities in materials such as iron, cobalt, and tungsten, which give many spectral lines, is nearly a hopeless task with low dispersion.

An X-ray plant could very profitably be installed in every foundry of any size. Castings of new and complicated design very often give trouble in the first batches. If the first castings of a new design were X-rayed the weak and faulty areas would immediately become apparent, and their detection would at once suggest the remedy.—V. E. Pullin in *The Engineer*, Dec. 19, 1930, p. 688.

---

[2] Discussion by Jacob Papish, Professor of Chemical Spectroscopy, Cornell University, Ithaca, N. Y.

[3] Discussion by Earle E. Schumacher, Bell Telephone Laboratories, Inc., New York, N. Y.

Thermal Properties of Compressed Liquid Water

By JOSEPH H. KEENAN,[1] HOBOKEN, N. J.

THE recent world-wide activity in steam research has revealed the characteristics of superheated steam throughout wide ranges of pressure and temperature which the older steam tables had covered by intelligent guesses or by ingenious speculation. But there has remained almost untouched that alluring region to the left of the steam dome where even the authors of steam tables have feared to tread. Only one experimenter, Amagat,[2] had carried out any very extensive investigations in this region (Bridgman's low-temperature work is of less significance here) before Keyes and Smith, with the methods so thoroughly proved in the superheat region, invaded the realm of the compressed liquid.

Enough was known about liquid water over the range of power-plant operation of ten years ago to justify the use of certain simple assumptions which satisfied the requirements of that time. For instance, it was always assumed that the specific volume of water does not change appreciably during compression in a feed pump, and hence the feed-pump work (f.p.w.) per pound of water is the product of the pressure rise and the initial specific volume; thus, $\text{f.p.w.} = \Delta p \times v$.

It was also assumed that the heat transferred to each pound of a continuous stream of liquid which is being heated from one temperature to a higher temperature is equal to the change in total heat between the saturated-liquid conditions at the two temperatures; thus, $\Delta Q = \Delta h_f$.

Both of these assumptions are merely approximations to the truth. If we were to set up a system consisting of a pump and a heater in series and were to introduce a stream of saturated liquid water into the pump at pressure p_1 and withdraw it from the heater in the saturated condition at pressure p_2, we should find from the energy equation that

$$\text{Feed-pump work} = h_2 - h_{f1}$$

$$\text{Heat added in heater} = h_{f2} - h_2$$

hence

$$h_{f2} - h_{f1} = \text{f.p.w.} + \text{heat added}$$

and

$$\text{Heat added} = (h_{f2} - h_{f1}) - \text{f.p.w.}$$

where h_{f1} = total heat of saturated liquid entering pump

h_2 = total heat of liquid leaving pump

h_{f2} = total heat of saturated liquid leaving heater.

The answer is that the old assumption so commonly used gives a value for the heat added between the feed pump and the boiling condition which is too large by an amount equal to the feed-pump work. For a boiler pressure of 200 lb. per sq. in. the error amounts to only 0.6 B.t.u. per lb. At 1200 lb. per sq. in. it becomes 3.5 B.t.u. per lb., and at 3200 lb. per sq. in. it is almost 10.0 B.t.u. per lb. When it is appreciated that those 3 to 10 B.t.u. per lb. must come from the generator terminals or an equivalent source where about 400 B.t.u. of work are being delivered per pound, it will be seen that the feed-pump work in the above equation is not to be ignored in high-pressure operation.

The other assumption, that compression of the liquid is a constant-volume process, should also be examined in the light of present-day operating conditions. The calculation of feed-pump work, like the calculation of the work turned out by a steam turbine, should be based on the adiabatic, reversible process—it is quite possible that a reciprocating feed pump more nearly approximates these conditions than does a reciprocating steam engine. Such a process is, by definition, a constant-entropy process, and the corresponding work of compression is the isentropic change in total heat.

One looks in vain through the various steam tables for data on entropy and total heat of liquid water other than saturated. The adequacy of the simple assumptions mentioned above for the operating range of a few years ago and the inadequacy of our experimental knowledge of water resulted in the restriction of steam-table data for the liquid to atmospheric pressure and the saturation line. Keyes and Smith have now given us the means of comparing the more accurate constant-entropy method with the usual constant-volume method of calculating feed-pump work.

The Keyes and Smith compressed-liquid specific-volume measurements extend from 480 to 680 deg. fahr., and from saturation to about 4800 lb. per sq. in.

---

[1] Assistant Professor of Mechanical Engineering, Stevens Institute of Technology. Assoc-Mem. A.S.M.E. Professor Keenan was graduated in 1922 from the course in naval architecture and marine engineering at the Massachusetts Institute of Technology, following which he entered the employ of the General Electric Company, Schenectady, N. Y., where he carried on research and development work relating particularly to steam flow. Since September, 1928, he has been on the faculty of Stevens Institute of Technology, at which institution he is now engaged in instruction and research.

[2] *Ann. de Chim. et de Phys.*, 6th series, vol. 29, August, 1893, p. 545.

Contributed by the A.S.M.E. Special Research Committee on Thermal Properties of Steam and presented at the Annual Meeting, New York, December 1 to 5, 1930, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

When coupled with the older Amagat measurements they form a comprehensive body of data which is more than adequate in extent, quality, and consistency for our present needs. Further data extending beyond the critical temperature would be of great interest and value in determining properties just above the steam dome. They would tie in with the Keyes and Smith superheated-vapor measurements between 700 and 750 deg. fahr., and would permit completing the steam table at pressures well above the critical pressure. But these considerations are of secondary importance, while the material just made available is of immediate practical interest.

The experimental data permitted the formulation of an almost complete grid of liquid specific volumes between the saturation line and 6000 lb. per sq. in. without undue extrapolation. This grid consisted of an approximate algebraic equation of state with a correction term

$$v = f(p, t) + \delta$$

The algebraic function, $f(p, t)$, was computed for the pressures and temperatures corresponding to the ex-

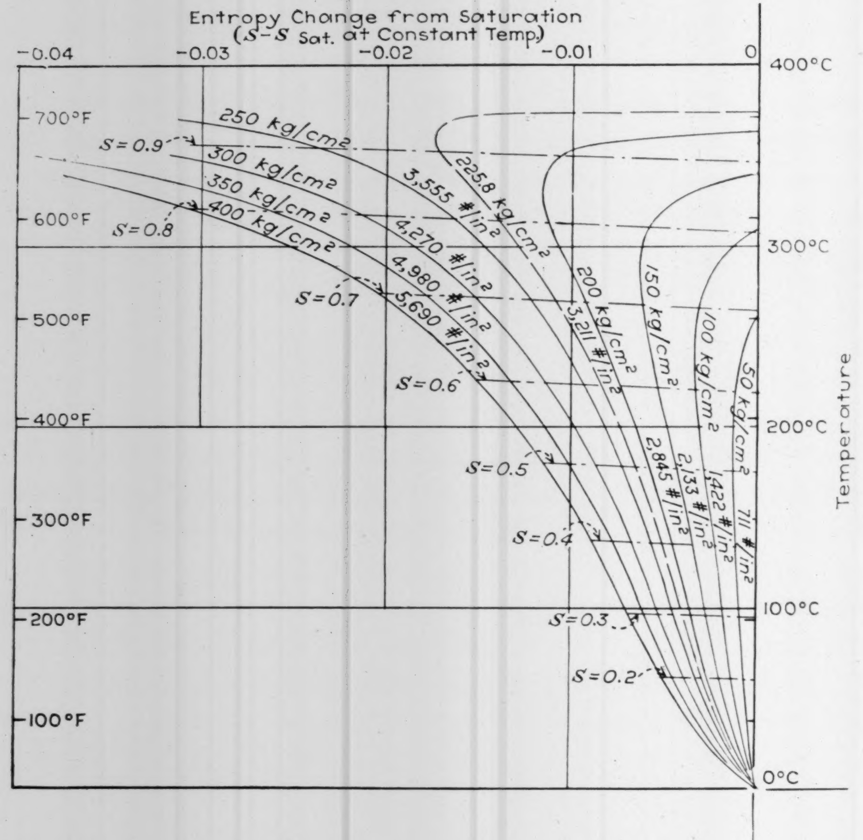


FIG. 1 DIFFERENCES IN ENTROPY OF WATER FROM THE SATURATION CONDITION AT CONSTANT TEMPERATURE

(Lines of constant entropy, S, are indicated.)

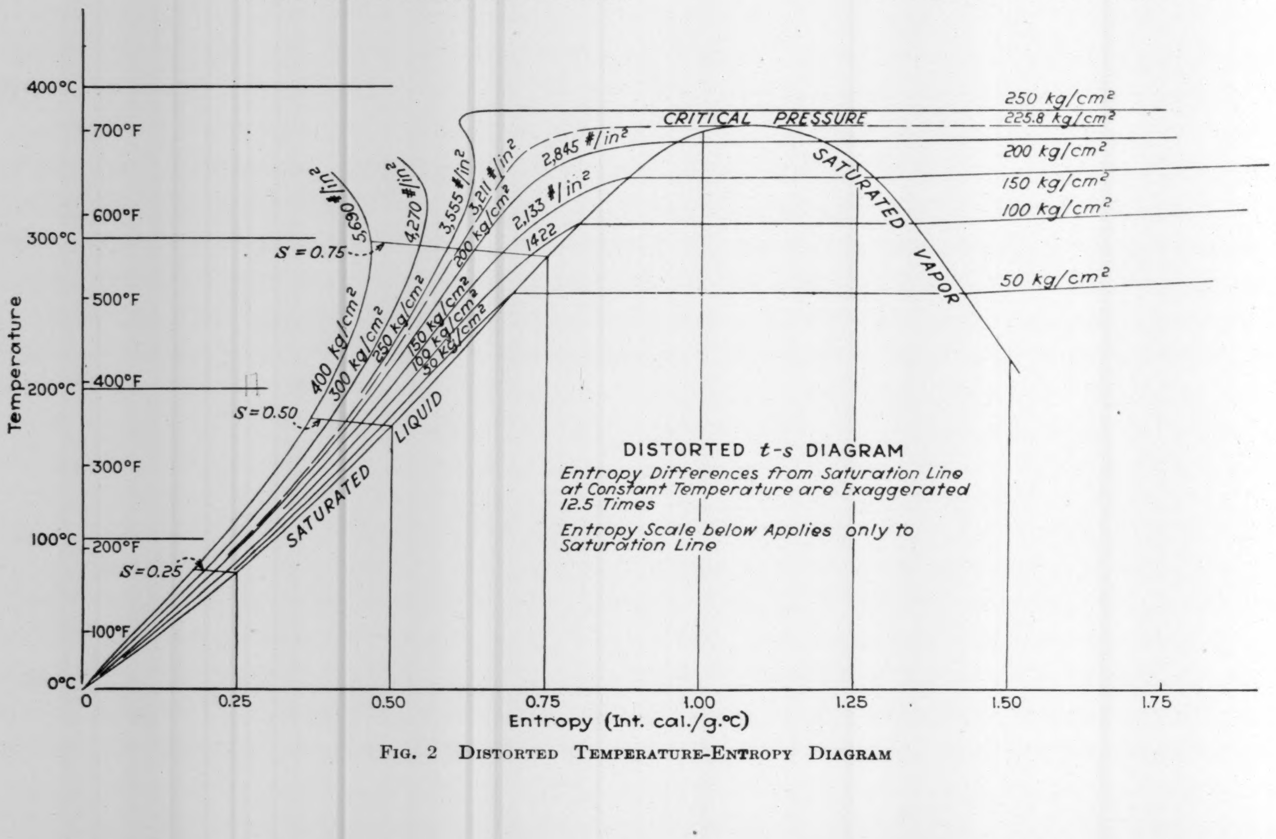


FIG. 2 DISTORTED TEMPERATURE-ENTROPY DIAGRAM

perimental values, and the δ was obtained by difference. Cross-faired charts of δ against p and t were developed from the experimental values. The result is a combination algebraic and graphic system of interpolation which can be differentiated and integrated relatively easily and to a high degree of consistency and which, furthermore, fits the experimental values within the experimental deviations.

There are two convenient thermodynamic relationships that relate volumes to total heats and entropies:

$$\left(\frac{\partial h}{\partial p}\right)_T = v - T\left(\frac{\partial v}{\partial T}\right)_p$$

$$\left(\frac{\partial s}{\partial p}\right)_T = -\left(\frac{\partial v}{\partial T}\right)_p$$

Integration at constant temperature from saturation yielded the changes in total heat and entropy from saturation to various pressures to a degree of accuracy higher than we can claim for any existing tabulation of saturation total heats and entropies.

The saturation values in the Keenan Steam Tables would be a fairly satisfactory set of integra-

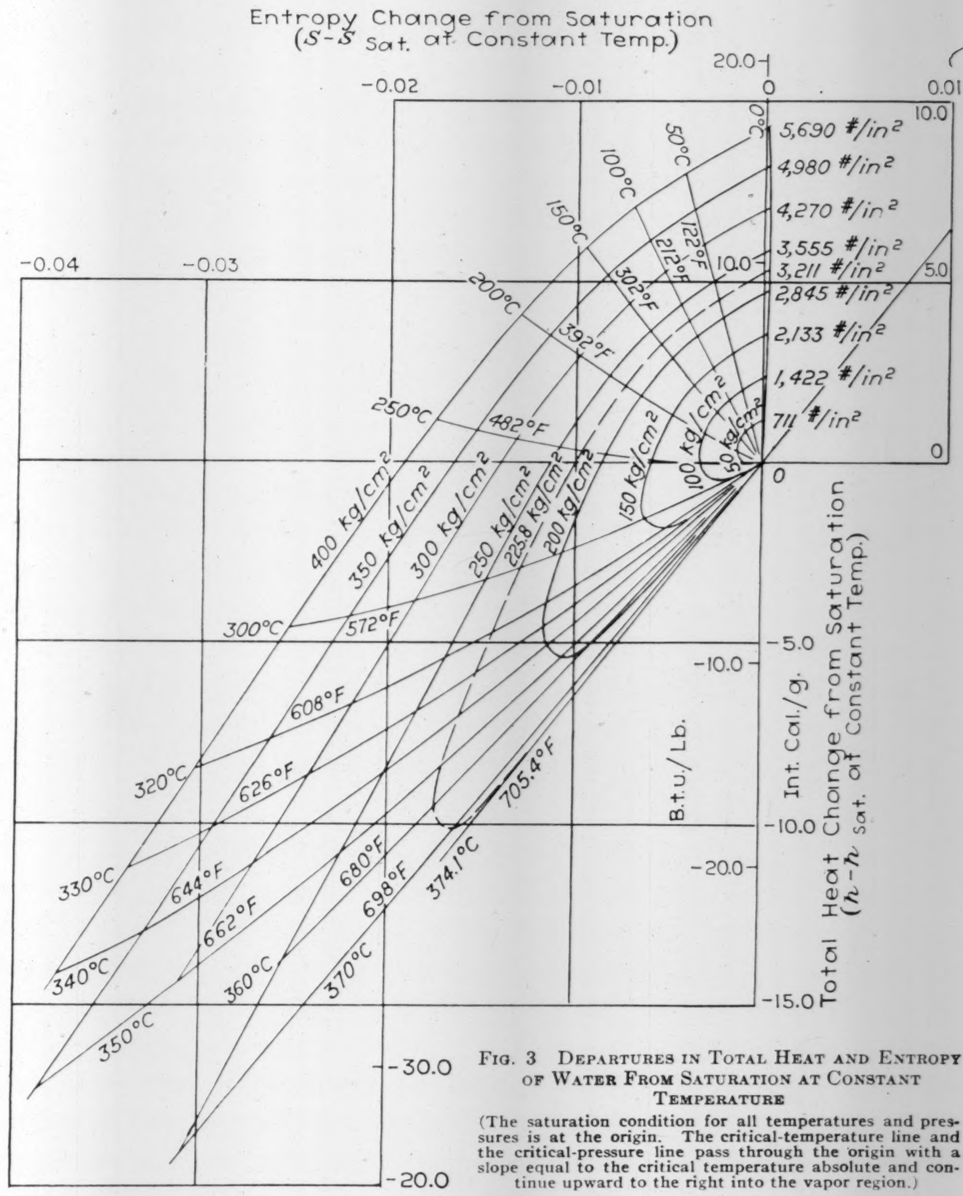


Fig. 3 Departures in Total Heat and Entropy of Water From Saturation at Constant Temperature

(The saturation condition for all temperatures and pressures is at the origin. The critical-temperature line and the critical-pressure line pass through the origin with a slope equal to the critical temperature absolute and continue upward to the right into the vapor region.)

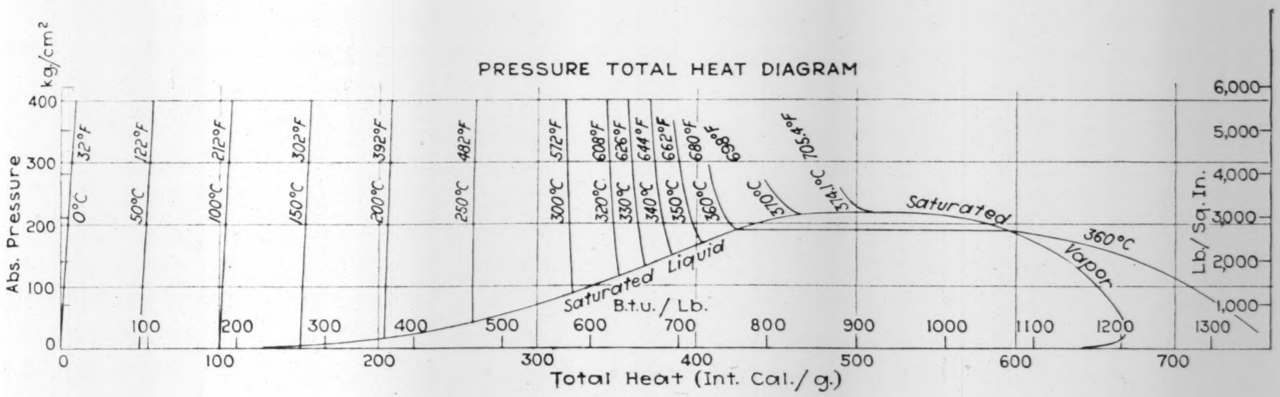


Fig. 4 Pressure–Total-Heat Diagram for Water

(Note the reversal in the slope of the constant-temperature lines at about 250 deg. cent. The 360-deg. cent. line is carried into the superheat region for comparison of characteristics.)

TABLE 1 COMPRESSED LIQUID

		Temperature, degrees fahrenheit											
		32°	100°	200°	300°	400°	500°	600°	650°	680°	700°	705.4°	
Saturated water	v	0.016021	0.016131	0.016633	0.017445	0.018634	0.020440	0.023615	0.025736	0.030297	0.0350	0.04943	
	h	0	67.93	167.92	269.47	374.85	487.45	619.9	702.2	764.4	833.2	924.8	
	s	0	0.12936	0.29376	0.43684	0.56638	0.68820	0.8153	0.8878	0.9407	0.9985	1.0765	
Abs. press., lb. per sq. in. (sat. temp.)													Saturated water
200 (381.82)	v	0.016010	0.016121	0.016623	0.017436	......	......	......	......	......	.....	.....	0.018381
	h	0.61	68.47	168.33	269.70	......	......	......	......	......	.....	.....	355.29
	s	0.00003	0.12931	0.29355	0.43663	......	......	......	......	......	.....	.....	0.54357
400 (444.66)	v	0.015999	0.016111	0.016612	0.017421	0.018618	......	......	......	......	.....	.....	0.019343
	h	1.21	69.02	168.80	270.08	375.01	......	......	......	......	.....	.....	423.93
	s	0.00004	0.12920	0.29329	0.43628	0.56598	......	......	......	......	.....	.....	0.62148
600 (486.30)	v	0.015987	0.016100	0.016600	0.017406	0.018595	......	......	......	......	.....	.....	0.020143
	h	1.80	69.60	169.23	270.44	375.24	......	......	......	......	.....	.....	471.34
	s	0.00007	0.12909	0.29302	0.43590	0.56542	......	......	......	......	.....	.....	0.67171
800 (518.31)	v	0.015976	0.016092	0.016590	0.017393	0.018574	0.020415	......	......	......	.....	.....	0.020874
	h	2.39	70.10	169.70	270.82	375.46	487.40	......	......	......	.....	.....	509.6
	s	0.00013	0.12896	0.29279	0.43557	0.56490	0.68767	......	......	......	.....	.....	0.7104
1000 (544.66)	v	0.015965	0.016081	0.016580	0.017380	0.018552	0.020368	......	......	......	.....	.....	0.021588
	h	2.99	70.63	170.13	271.22	375.69	487.31	......	......	......	.....	.....	543.0
	s	0.00015	0.12883	0.29256	0.43520	0.56438	0.68679	......	......	......	.....	.....	0.7430
1500 (596.16)	v	0.015938	0.016057	0.016553	0.017345	0.018498	0.020259	......	......	......	.....	.....	0.023443
	h	4.48	71.92	171.28	272.17	376.29	487.16	......	......	......	.....	.....	614.5
	s	0.00020	0.12850	0.29197	0.43431	0.56306	0.68465	......	......	......	.....	.....	0.8100
2000 (635.64)	v	0.015912	0.016033	0.016526	0.017311	0.018444	0.020154	0.023303	......	......	.....	.....	0.025616
	h	5.97	73.24	172.43	273.11	376.88	487.07	617.4	......	......	.....	.....	677.2
	s	0.00022	0.12818	0.29137	0.43342	0.56181	0.68263	0.8110	......	......	.....	.....	0.8661
2500 (667.92)	v	0.015885	0.016009	0.016500	0.017277	0.018391	0.020055	0.023010	0.026176	......	.....	.....	0.028535
	h	7.49	74.51	173.55	274.02	377.51	487.04	615.0	697.4	......	.....	.....	736.9
	s	0.00025	0.12788	0.29079	0.43259	0.56059	0.68067	0.8068	0.8823	......	.....	.....	0.9175
3000 (695.30)	v	0.015859	0.015985	0.016474	0.017242	0.018339	0.019961	0.022750	0.025477	0.028817	.....	.....	0.03421
	h	9.00	75.81	174.68	274.96	378.18	487.04	613.0	691.0	752.4	.....	.....	811.1
	s	0.00028	0.12757	0.29020	0.43172	0.55935	0.67879	0.8029	0.8743	0.9286	.....	.....	0.9799
3211.60	v	0.015847	0.015975	0.016463	0.017227	0.018318	0.019922	0.022649	0.025240	0.028142	0.03284	0.04943	0.04943
	h	9.61	76.38	175.17	275.37	378.47	487.05	612.2	688.8	747.0	815.6	924.8	924.8
	s	0.00029	0.12743	0.28996	0.43134	0.55884	0.67801	0.8013	0.8713	0.9228	0.9832	1.0765	1.0765
3500	v	0.015832	0.015963	0.016449	0.017207	0.018289	0.019871	0.022518	0.024939	0.027434	.....	.....	......
	h	10.44	77.10	175.82	275.91	378.86	487.11	611.3	686.1	741.0	803.0	892.1	......
	s	0.00030	0.12728	0.28962	0.43087	0.55817	0.67697	0.7993	0.8677	0.9166	0.9699	1.0465	......
4000	v	0.015807	0.015940	0.016424	0.017174	0.018239	0.019787	0.022307	0.024492	0.026557	.....	.....	......
	h	11.88	78.42	176.95	276.88	379.56	487.29	609.8	682.3	733.6	.....	.....	......
	s	0.00029	0.12694	0.28902	0.43007	0.55698	0.67518	0.7960	0.8622	0.9078	.....	.....	......
4500	v	0.015781	0.015918	0.016399	0.017142	0.018190	0.019707	0.022114	0.024113	0.025900	.....	.....	......
	h	13.35	79.73	178.07	277.87	380.25	487.47	608.6	679.0	......	.....	.....	......
	s	0.00026	0.12662	0.28843	0.42924	0.55580	0.67341	0.7929	0.8572	......	.....	.....	......
5000	v	0.015755	0.015896	0.016374	0.017109	0.018143	0.019627	0.021936	0.023785	0.025368	.....	.....	......
	h	14.75	81.01	179.22	278.83	380.93	487.70	607.6	676.1	......	.....	.....	......
	s	0.00022	0.12629	0.28784	0.42844	0.55464	0.67174	0.7901	0.8527	......	.....	.....	......
5500	v	0.015730	0.015875	0.016350	0.017077	0.018097	0.019549	0.021768	0.023475	0.024940	.....	.....	......
	h	16.18	82.34	180.39	279.83	381.63	487.97	606.7	673.5	......	.....	.....	......
	s	0.00020	0.12597	0.28729	0.42764	0.55353	0.67011	0.7872	0.8483	......	.....	.....	......
6000	v	0.015705	0.015854	0.016326	0.017044	0.018052	0.019471	0.021600	0.023158	0.024580	.....	.....	......
	h	17.60	83.65	181.54	280.86	382.35	488.22	605.9	671.3	......	.....	.....	......
	s	0.00010	0.12564	0.28670	0.42684	0.55243	0.66864	0.7845	0.8442	......	.....	.....	......

tion constants for these integrations, but since the completion of the steam-table development more has been learned about the saturated liquid. Osborne, Stimson, and Fiock have revised and extended their measurements, and Keyes and Smith have given us the means of determining latent heats through the Clapeyron relation almost to the critical point. It happens that the Osborne saturated-vapor measurements have to their upper limit justified the means used to obtain the saturated-vapor total heats in the Keenan tables. Consequently a revision of saturated-liquid values was made which consists of the Osborne values to 270 deg. cent., and above that the Keenan saturated-vapor values less the vaporization change indicated by Keyes and Smith. These values carefully smoothed to the critical point were used as the starting points for the integrations into the region of the compressed liquid.

The entropy changes from saturation shown in Fig. 1 are so small as compared with the saturation entropies that it was necessary to distort the temperature-entropy diagram, Fig. 2, in order to exhibit the characteristics of the constant-pressure lines. It is interesting to note the crossing of the saturation line at about 4 deg. cent., the point of maximum density.

The total-heat change from saturation is plotted against the entropy change from saturation, both at constant temperature, in Fig. 3. The coordinates of this chart are to such a large scale that they can be read to one and sometimes two significant figures beyond our knowledge of the saturation-line values. Revisions of the saturation values will not affect the validity of this chart because it is based entirely on liquid specific-volume data. To obtain the total heat at any pressure and temperature in the compressed-liquid region it is only necessary to read from this chart the value of the ordinate and add to it the saturated-liquid total heat at the given temperature. A similar method using the abscissa gives the entropy. Table 1 was obtained by this process, using the revised saturation values discussed above.

A word should be said about the portion of this chart above 350 deg. cent., beyond which, because of the extreme uncertainty of extrapolation, the volume derivatives necessary to the entropy and total-heat computations could not be obtained satisfactorily. In Fig. 3 the slope of the critical temperature and pressure lines at the critical point where they coincide is the critical temperature absolute, 647.2 deg. Kelvin. In the superheat region these two lines retain this slope and keep close company for an extraordinary distance to the right. In the liquid region the departure from the straight line is small and can be estimated quite closely. Interpolation for the 360- and 370-deg. cent. lines was consequently relatively simple.

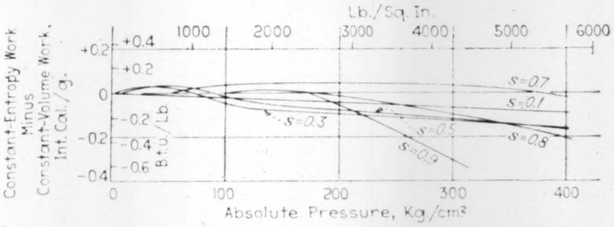


FIG. 5 CONSTANT-ENTROPY FEED-PUMP WORK COMPARED WITH CONSTANT-VOLUME WORK

(Each line represents the differences for compression beginning with the saturation condition and continuing at constant entropy. Thus, the abscissa is the pump discharge pressure. The pump suction pressure is the saturation pressure corresponding to the entropy value for the line. The constant-entropy work is the change in total heat along the constant-entropy line. The constant-volume work is the rise in pressure from the saturation condition multiplied by the specific volume at the saturation condition.)

Fig. 4 is a pressure–total-heat chart similar to that shown last year by Professor Heck for CO_2.[3] It shows clearly the change in slope of the constant-temperature lines from an increase in total heat with increased pressure in the low-temperature region to a decrease in total heat with increased pressure in the high-temperature region. This latter characteristic is the one with which we are familiar in the superheat region and corresponds to a positive Joule-Thomson coefficient.

In Fig. 1 some constant-entropy lines are shown, and it is interesting to note how small is their departure from constant-temperature lines even at an entropy of 0.9. Table 2 gives the temperature rise at constant entropy for compression to two different pressures.

TABLE 2 TEMPERATURE RISE AT CONSTANT ENTROPY FOR COMPRESSION TO TWO DIFFERENT PRESSURES

			Constant-entropy rise in temperature	
Entropy	Saturation temperature, deg. fahr.	Saturation pressure, lb. per sq. in. abs.	To critical pressure, deg. fahr.	To 5690 lb. per sq. in., deg. fahr.
0.1	83.71	0.55	0.81	1.55
0.3	204.06	12.51	2.50	4.46
0.5	347.51	136.44	4.97	8.84
0.7	509.34	739.5	8.89	16.75
0.8	588.34	1413.6	10.23	22.41
0.9	657.23	2324.3	10.15	...

The work done by our reversible adiabatic feed pump can now be found from total-heat changes along constant-entropy lines. In Fig. 5 this isentropic work is compared with the work as calculated from the old constant-volume assumption. Here the constant-volume work is simply the rise in pressure multiplied by the initial specific volume—each compression starting from saturation at the entropy indicated.

The differences are astonishingly small, usually within 2 per cent of the compression work. Probably for all practical purposes the constant-volume work is a satisfactory approximation to the constant-entropy work, but where greater accuracy is desired the constant-entropy work may be found by applying the correction indicated by Fig. 5 to the constant-volume calculation.

The introduction of higher pressures has forced the power-plant engineer to revise and usually to complicate his methods of calculation. Though it was not long ago that he could assume the latent heat of vaporization to be the same at all temperatures, today he may not assume that the heat added to the liquid is equal to the change in h_f, or that the specific heat of water is unity. Perhaps he will derive some comfort from this assurance that he may continue to calculate feed-pump work in the good old-fashioned way.

The Reed-Lamie Process of Low-Temperature Carbonization

THIS process was developed for use with high-volatile coal and is now being carried out in a pilot plant in Detroit. One of the features is the effort to conserve the sensible heat content in the semi-coke and take advantage of the ease with which the hot semi-coke flashes into flame. In the process a gas-tight revolving retort is used and slack coal is fed into it. The interior of the retort is divided in a series of chambers, and within each of these chambers is placed a loose mass of impact bodies, some spherical, some angular. The size, weight, and proportion of angular to spherical bodies are not the same in all chambers, but are selected according to the work which they have to do. Their main functions are to transmit it to the distilling mass and to keep the walls of the retort free of carbon.

One of the products of the process is semi-coke in hot powdered form. It is remarkable for its mobility and will flow freely. Therefore there is no arching as with pulverized raw coal.

Of the by-products the tar shows a fairly high fraction, boiling within the gasoline range. This fraction consists almost entirely of aliphatic hydrocarbons and benzol, while cyclic hydrocarbons if present are in small amounts only. It is stated that this fraction when tested in a standard detonating engine shows a 100 per cent benzol equivalent and can thus be used as a blending material for the production of an anti-knock motor fuel. The next higher boiling fraction contains low-boiling phenols and a neutral oil, the phenol consisting largely of cresylic acid. The neutral oils can be used only as fuel oils, but the entire tar can be cracked to produce a motor fuel with high anti-knock characteristics. The semi-coke can be directly fired under a boiler.—*Power*, Dec. 9, 1930, p. 941.

---

[3] MECHANICAL ENGINEERING, vol. 52, Feb., 1930, pp. 133–139.

Some Final Values for the Properties of Saturated and Superheated Water[1]

By FREDERICK G. KEYES[2] AND LEIGHTON B. SMITH,[3] CAMBRIDGE, MASS.

F. G. KEYES

LAST spring, in preparation for the second international conference, practically all the available Massachusetts Institute of Technology experimental data pertaining to the properties of water were reduced and tabulated. The object of the present communication is to record these values and exhibit a few comparisons of derived quantities with the corresponding quantities measured by our colleagues Nathan S. Osborne, H. F. Stimson, and E. F. Fiock. The comparisons indicate a wholly satisfactory and gratifying degree of concordance.

Some of the data have been presented before, particularly the vapor-pressure data, and doubtless it will be a source of as much satisfaction to others as to the authors that the table of values for the saturated pressure-temperature relations of water herewith presented is a final revision.

A table of $(dp/dT)_{\text{sat.}}$ values for 10-deg. intervals from 0 to 370 deg. cent. is given, which values are believed to be the most reliable and consistent of any hitherto published. It is possibly worth remarking that it is not easy to obtain exact derivatives even when reliable primary data are available. The method employed in the present instance is one developed by Prof. George Rutledge.[4] Later a table of values will be given for each degree.

Superheated-water-vapor values previously presented have been very difficult to obtain because of the decomposition of the steam by the container material. Moreover at high temperatures, or rather at temperatures greater than 325 deg. cent. (617 deg. fahr.), mercury cannot be used to confine the fluid, and water itself has been used as the confining fluid. The latter procedure has its limitations from the point of view of the precision sought for in the steam-research program. Happily, during the year a solution of the steam decomposition difficulty has been found in the

TABLE 1 VAPOR PRESSURES OF WATER IN ATMOSPHERES

(Critical temperature, 374.11 deg. cent.; critical pressure, 218.53 atmos.; critical volume, 3.086 cc. per gram.)

t, deg. cent.	0	1	2	3	4	5	6	7	8	9
100	1.0000	1.0363	1.0736	1.1120	1.1515	1.1921	1.2340	1.2771	1.3215	1.3671
110	1.4139	1.4621	1.5116	1.5624	1.6147	1.6684	1.7236	1.7803	1.8385	1.8982
120	1.9595	2.0223	2.0869	2.1532	2.2212	2.2908	2.3621	2.4352	2.5102	2.5872
130	2.6662	2.7469	2.8296	2.9144	3.0012	3.0901	3.1811	3.2742	3.3695	3.4671
140	3.5669	3.6690	3.7735	3.8804	3.9897	4.1014	4.2156	4.3323	4.4516	4.5736
150	4.6982	4.8255	4.9556	5.0885	5.2242	5.3627	5.5041	5.6486	5.7961	5.9467
160	6.1003	6.2571	6.4170	6.5801	6.7465	6.9163	7.0895	7.2661	7.4462	7.6298
170	7.8169	8.0075	8.2019	8.4000	8.6019	9.8076	9.0171	9.2305	9.4480	9.6694
180	9.8949	10.127	10.362	10.601	10.844	11.090	11.340	11.595	11.854	12.117
190	12.385	12.659	12.937	13.220	13.508	13.801	14.099	14.402	14.709	15.022
200	15.341	15.664	15.992	16.326	16.666	17.011	17.361	17.717	18.079	18.446
210	18.819	19.198	19.583	19.974	20.371	20.774	21.182	21.598	22.020	22.448
220	22.881	23.322	23.769	24.223	24.684	25.151	25.625	26.106	26.594	27.089
230	27.591	28.100	28.616	29.139	29.670	30.208	30.754	31.307	31.868	32.437
240	33.013	33.598	34.190	34.790	35.398	36.014	36.638	37.271	37.912	38.562
250	39.220	39.887	40.562	41.246	41.939	42.641	43.352	44.072	44.800	45.538
260	46.286	47.043	47.809	48.585	49.371	50.166	50.971	51.786	52.611	53.446
270	54.290	55.145	56.011	56.887	57.773	58.690	59.577	60.495	61.424	62.364
280	63.315	64.278	65.251	66.235	67.231	68.238	69.257	70.288	71.330	72.384
290	73.450	74.528	75.618	76.720	77.834	78.961	80.100	81.252	82.418	83.596
300	84.785	85.988	87.205	88.434	89.678	90.935	92.205	93.489	94.786	96.098
310	97.423	98.762	100.116	101.484	102.866	104.265	105.676	107.102	108.544	110.001
320	111.473	112.960	114.463	115.982	117.516	119.066	120.632	122.215	123.814	125.429
330	127.060	128.709	130.374	132.055	133.751	135.473	137.207	138.958	140.727	142.515
340	144.321	146.145	147.987	149.848	151.727	153.626	155.543	157.479	159.435	161.411
350	163.407	165.422	167.457	169.513	171.590	173.687	175.804	177.943	180.103	182.285
360	184.489	186.712	188.958	191.226	193.518	195.833	198.171	200.533	202.919	205.329
370	207.874[1]	210.350[1]	212.881[1]	215.497[1]	218.192[1]	.....	.....	.....	.....	...

[1] Experimental values.

TABLE 2 dp/dt AT SATURATION FOR WATER, IN ATMOSPHERES PER DEGREE CENTIGRADE

t	$\frac{dp}{dt}$	t	$\frac{dp}{dt}$
0	0.0004365	190	0.27136
10	0.0008111	200	0.3207
20	0.001428	210	0.3760
30	0.002403	220	0.4375
40	0.003879	230	0.5055
50	0.006038	240	0.5803
60	0.009096	250	0.6623
70	0.01330	260	0.7521
80	0.01893	270	0.8501
90	0.02629	280	0.9565
100	0.03571	290	1.0719
110	0.04752	300	1.1969
120	0.06210	310	1.332
130	0.07979	320	1.480
140	0.10096	330	1.640
150	0.12596	340	1.815
160	0.15517	350	2.005
170	0.18892	360	2.214
180	0.22754	370	2.444

---

[1] Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology, Publication No. 254.

[2] Director of Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology. Dr. Keyes received his B.S. from Rhode Island College in 1906, and his M.S. and Ph.D. from Brown University in 1907 and 1909. From 1910 to 1913 he was research associate in physical chemistry at M.I.T., and then for three years was chief engineer of the Cooper-Hewitt Electric Co. In 1916 he returned to M.I.T. as associate professor of physical chemistry research, and in 1920 was appointed director of the laboratory. Since 1922 he has also been head of the chemistry department.

[3] Assistant Professor of Physico-Chemical Research, Massachusetts Institute of Technology.

Contributed by the A.S.M.E. Special Research Committee on Thermal Properties of Steam and presented at the Annual Meeting, New York, December 1 to 5, 1930, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[4] Geo. Rutledge, *Jl. Math. & Physics*, M.I.T., vol. 8, p. 1, 1929. See also Trans. Am. Math. Soc., vol. 26 (1924), p. 113.

use of an 18 per cent chromium-8 per cent nickel steel, and earlier measurements have been in part already repeated, using the new container. Not only have the measurements been repeated, but it has been found possible to extend the older, upper limit of the temperature from 400 deg. cent. to 460 deg. cent. (860 deg. fahr).

TABLE 3 SPECIFIC VOLUMES OF SATURATED STEAM

(1) Obtained through the Clapeyron relation using values of the latent heat given by a smoothing equation resulting from an attempt to correlate [see footnote (2), Table 5] the latent heats of Leighton B. Smith and Frederick G. Keyes.

(2) Computed from the γ_θ function measured by Nathan S. Osborne, H. F. Stimson, and E. F. Fiock, using values of dp/dt resulting from the measurements of the vapor pressure of steam by Leighton B. Smith and Frederick G. Keyes.

t	(1)	(2)
100	1672.9[1]	1673.1
110	1209.7[1]	(1210.1)[2]
120	891.2[1]	(891.5)
130	667.7[1]	668.0
140	......	(508.5)
150	......	392.5
160	......	(306.8)
170	......	242.7
180	......	(193.9)
190	......	(156.5)
200	......	127.3
210	......	(104.4)
220	......	86.16
230	......	(71.58)
240	......	(59.73)
250	50.16	50.10
260	42.12	(42.17)
270	35.47	35.60
280	30.00	....
290	25.38	....
300	21.48	....
310	18.17	....
320	15.31	....
330	12.85	....
340	10.68	....
350	8.74	....
360	6.92	....
370	4.98	....

---

[1] Computed by equation of state for low-pressure steam:

$$pV = 4.555T\left[1 + \left\{8.7 - \frac{35{,}800}{4.555T}\left(1 + 0.012 \times 10^{\frac{649}{T}}\right)\right\}\frac{1}{V}\right]$$

[2] The values in parentheses are γ_θ values interpolated by Osborne, Stimson, and Fiock.

TABLE 4

(1) Saturated specific volumes of steam.
(2) Values of dp/dT from vapor pressures.
(3) Calculated latent heats by Clapeyron equation.
(4) Latent heats from the Nathan S. Osborne, H. F. Stimson, and E. F. Fiock equation based on their measurements from 100 deg. to 270 deg.

t	V_1 (1)	$\frac{dp}{dT}$ (2)	$L_{\text{cal.}}$ (3)	$L_{\text{O.S.F. Eq.}}$ (4)
0	206368[1]	0.0004365	595.5	595.8
10	106338[1]	0.0008112	591.1	590.5
20	57795[1]	0.0014280	585.5	585.3
30	32911[1]	0.0024027	580.2	580.0
40	19538[1]	0.0038794	574.3	574.5
50	12045[1]	0.0060384	568.8	568.9
60	7680[1]	0.0090959	563.2	563.3
70	5047[1]	0.013300	557.4	557.5
80	3410[1]	0.018930	551.5	551.5
90	2362[1]	0.026293	545.5	545.5
100	1673[1]	0.035710	539.2	539.2
125	769.7[1]	0.070536	522.5	522.8
191.93	150.0[2]	0.28048	470.0	470.8
213.32	97.5[2]	0.39581	448.9	450.6
227.35	75.0[2]	0.48683	435.2	436.1
263.05	40.0[2]	0.78112	392.5	392.8
304.10	20.0[3]	1.2511	325.1	325.8
312.20	17.5[3]	1.3638	309.5	309.1
321.34	15.0[3]	1.5005	291.4	287.8
331.64	12.5[3]	1.6677	266.8	...
343.27	10.0[3]	1.8752	233.2	...
356.63	7.5[3]	2.1417	185.2	...
363.71	6.25[3]	2.2971	150.7	...
370.54	5.00[3]	2.4581	98.2	...

---

[1] From equation of state for low-pressure (1–2 atmos.) steam:

$$pV = 4.555T\left[1 + \left\{8.7 - \frac{35{,}800}{4.555T}\left(1 + 0.012 \times 10^{\frac{649}{T}}\right)\right\}\frac{1}{V}\right]$$

[2] From extrapolation of isometrics to vapor pressure. Original pressures corrected.

[3] Extrapolation of isometrics to vapor pressure.

The data for superheated steam at 20 cc. per gram will require some modification, as will also the data at smaller volumes. Prof. L. B. Smith discusses the new container and the present status of the superheat values in another article appearing in the present issue of MECHANICAL ENGINEERING.

Tables 3, 4, and 5 contain extrapolated quantities: the specific volumes of saturated-steam vapor. The values from 300 deg. fahr. to higher temperatures on the basis of the most recent measurements in the chromium-nickel-alloy container will be somewhat greater. For example, as an estimate, the saturated volume at 300 deg. cent. may be increased from the value 21.48 cc. per gram given in Table 3 to 21.52 cc. per gram.

Saturation values at temperatures less than 191.93 deg., Table 4, have been computed from an extrapolation by an equation of state based on the pressures and temperatures for isometrics at 150, 97.5, 75, and 40

TABLE 5 LATENT HEATS COMPUTED BY THE CLAPEYRON EQUATION USING SPECIFIC VOLUMES OF THE SATURATED VAPOR OBTAINED BY EXTRAPOLATION OF THE SUPERHEAT ISOMETRICS TO THE VAPOR PRESSURES, TOGETHER WITH dp/dt FROM THE VAPOR-PRESSURE MEASUREMENTS

t, deg. cent.	L, Clapeyron	L(1) O.S.F.	L(2)	t, deg. cent	L(1) O.S.F.	L(2)
263.05	392.5	392.8	392.5	250	409.8	410.5
304.1	325.1	325.8	325.7	260	396.9	396.8
312.2	309.9	309.1	309.9	270	383.1	382.4
321.34	291.4	287.8	290.6	280	368.1	367.1
331.64	266.8	261.2	266.1	290	351.7	350.8
343.27	233.2	224.8	233.9	300	333.7	333.3
356.63	185.2	169.5	185.9	310	313.8	314.3
363.71	150.7	128.8	150.7	320	291.4	293.5
370.54	98.2	69.4	97.8	330	265.8	270.2
....	...	...	...	340	235.8	243.6
....	...	...	...	350	199.3	211.7
....	...	...	...	360	151.6	170.5
....	...	...	...	370	75.6	103.6

---

(1) $L = 0.00061204\,(374 - t)^2 - 1.4054\,(374 - t) + 59.699\,(374 - t)^{1/3} - 26.9946\,(374 - t)^{1/4}$. (Valid to 270 deg. cent.)
Equation given by Osborne, Stimson, and Fiock.

(2) Calculated by equation based on L (Clapeyron):
$$L = 58.483\,(374.11 - t)^{0.404198}$$

TABLE 6 LIQUID WATER: SPECIFIC VOLUME AT SATURATION PRESSURE

(Cubic centimeters per gram)

t	V_{smoothed}	$V_{\text{obs.}}$	t	V_{smoothed}	$V_{\text{obs.}}$
100	1.04343	1.04343	230	1.20904	.....
110	1.05157	.....	240	1.22959	.....
120	1.06029	.....	250	1.25189	1.25134
130	1.06963	.....	260	1.27606	.....
140	1.07962	.....	270	1.30264	.....
150	1.09029	1.09017	280	1.33224	.....
160	1.10170	.....	290	1.36547	.....
170	1.11391	.....	300	1.40323	1.40366
180	1.12700	.....	310	1.44685	1.44743
190	1.14107	.....	320	1.49819	1.49857
200	1.15620	1.15625	330	1.56023	1.55991
210	1.17250	.....	340	1.63749	1.63708
220	1.19007	.....	350	1.73928	1.73900
...	.....	.....	360	1.89139	1.89180
...	.....	.....	374.1	3.086[1]	.....

---

[1] Critical volume from "rect. diam."

TABLE 7 LIQUID WATER: DENSITY AT SATURATION PRESSURE

(Grams per cubic centimeter)

t	δ_{smoothed}	$\delta_{\text{obs.}}$	t	δ_{smoothed}	$\delta_{\text{obs.}}$
100	0.95838	0.95838	230	0.82710	.....
110	0.95096	.....	240	0.81328	.....
120	0.94314	.....	250	0.79879	0.79914
130	0.93491	.....	260	0.78366	.....
140	0.92626	.....	270	0.76767	.....
150	0.91719	0.91729	280	0.75061	.....
160	0.90769	.....	290	0.73235	.....
170	0.89774	.....	300	0.71264	0.71242
180	0.88731	.....	310	0.69116	0.69088
190	0.87637	.....	320	0.66747	0.66730
200	0.86490	0.86486	330	0.64093	0.64106
210	0.85288	.....	340	0.61069	0.61084
220	0.84029	.....	350	0.57495	0.57504
...	.....	.....	360	0.52871	0.52860

TABLE 8 SATURATED SPECIFIC VOLUMES OF LIQUID WATER

(Volumes in cc. per gram)

(1) Measured, Leighton B. Smith and Frederick G. Keyes.

(2) Deduced from β_θ function of Nathan S. Osborne, H. F. Stimson, and E. F. Fiock by the operation:

$$\frac{\beta\theta \times 9.869}{T\frac{dp}{dt}} = v_2 \text{ cc. per gram.}$$

(3) Deduced from β_θ values of (2) as smoothed by Osborne, Stimson, and Fiock.

(4) I. C. T.

t	(1)	(2)	(3)	(4)
100	1.04343	1.0437	1.0429	1.0434
110	1.05157	1.0571	1.0511	1.0510
120	1.06029	1.0564	1.0606	1.0592
130	1.06963	1.0703	1.0690	1.0680
140	1.07962	1.0814	1.0797	1.0776
150	1.09029	1.0929	1.0909	1.0881
160	1.10170	1.1026	1.1029	1.0997
170	1.11391	1.1191	1.1157	1.1124
180	1.12700	....	1.1295	1.1262
190	1.14107	....	1.1441	1.1410
200	1.15620	1.1592	1.1598	1.1569
210	1.17250	....	1.1762	1.1739
220	1.19007	1.1910	1.1935	1.1919
230	1.20904	1.2111	1.2118	1.211
240	1.22959	1.2320	1.2311	1.231
250	1.25189	1.2517	1.2513	1.252
260	1.27606	....	1.2717	1.274
270	1.30264	1.3040	1.3042	1.297

TABLE 8-A VOLUMES OF LIQUID WATER UNDER PRESSURE

150 deg. cent.		200 deg. cent.	
P (atmos.)	V (cc./g.)	P (atmos.)	V (cc./g.)
.....	1.09029 (smoothed)	.....	1.15620 (smoothed)
4.698	1.09017 (sat.)	15.341	1.15625 (sat.)
24.192	1.08887	24.261	1.15535
54.486	1.08686	54.552	1.15231
84.777	1.08487	84.843	1.14934
115.068	1.08290	115.135	1.14634
145.360	1.08098	145.425	1.14354
175.654	1.07907	175.717	1.14079
205.944	1.07715	206.008	1.13809
236.237	1.07539	236.300	1.13542
266.529	1.07357	266.591	1.13279
296.822	1.07176	296.882	1.13027
327.115	1.07001	327.175	1.12780

TABLE 9 VOLUMES OF LIQUID WATER UNDER PRESSURE

250.00 deg. cent.		300.00 deg. cent.		350.00 deg. cent.	
P (atmos.)	V (cc./g.)	P (atmos.)	V (cc./g.)	P (atmos.)	V (cc./g.)
39.220	1.25134 (sat.)	84.785	1.40366 (sat.)	163.407	1.73900 (sat.)
54.640	1.24854	.....	.....	.....	.....
84.929	1.24320	.....	.....	.....	.....
115.218	1.23806	115.335	1.39068	.....	.....
145.508	1.23310	145.619	1.37884	166.730	1.72989
175.798	1.22837	175.907	1.36803	175.808	1.70729
206.088	1.22381	206.193	1.35797	206.075	1.65088
236.378	1.21938	236.431	1.34864	236.349	1.61043
266.668	1.21521	266.767	1.33992	266.626	1.57851
296.959	1.21123	297.056	1.33178	296.906	1.55213
327.250	1.20722	327.345	1.32406	327.188	1.52952

TABLE 9-A VOLUMES OF LIQUID WATER UNDER PRESSURE

(May, 1930)

310.00 deg. cent.		320.00 deg. cent.		330.00 deg. cent.		340.00 deg. cent.		360.00 deg. cent.	
P (atmos.)	V (cc./g.)	P (atmos.)	V (cc./g.)	P (atmos.)	V (cc./g.)	P (atmos.)	V (cc./g.)	P (atmos.)	V (cc./g.)
97.423	1.44740[1]	111.473	1.49857[1]	127.060	1.56004[1]	144.321	1.63703[1]	184.489	1.89180[1]
115.075	1.43768	115.110	1.49583	130.292	1.55666	.....	.....	184.972	1.88835
145.358	1.42227	145.391	1.47464	145.430	1.54148	145.479	1.63524	.....	.....
175.653	1.40853	175.674	1.45640	175.709	1.51549	175.752	1.59284	.....	.....
205.931	1.39600	205.958	1.44035	205.990	1.49356	206.028	1.56059	206.138	1.79242
236.215	1.38463	236.243	1.42606	236.273	1.47474	236.308	1.53437	236.400	1.71631
266.502	1.37413	266.528	1.41297	266.557	1.45810	266.589	1.51206	266.670	1.66534
296.790	1.36432	296.815	1.40105	296.842	1.44312	296.872	1.49265	296.945	1.62684
.....	.....	327.102	1.39001	327.128	1.42956	327.157	1.47549	327.224	1.59549

---

[1] Saturated. $V_{(\text{sat.})}$ at 370.00 deg. cent. = 2.1988 cc. per gram.
(From "rect. diam." and saturated-vapor volume at 370.00 deg. cent.)

TABLE 10 ISOMETRICS OF SUPERHEATED STEAM—SERIES I

T, deg. cent.	5.0	6.25	7.5	10.0	12.5	15.0	17.5	20.0
	Pressures in atmospheres							
310	....	....	....	....	....	....	....	92.01
320	....	....	....	....	....	....	103.80	95.75
330	....	....	....	....	....	118.01	108.17	99.40
340	....	....	....	....	135.28	123.23	112.38	102.92
350	....	....	....	156.31	141.73	128.27	116.49	106.34
360	....	....	181.18	164.72	148.06	133.20	120.50	109.70
370	....	201.79	192.95	172.90	154.13	138.00	124.42	113.00
380	225.68	215.89	204.36	180.84	160.08	142.68	128.26	116.23
390	243.19	229.66	215.47	188.61	165.91	147.28	132.01	119.40
400	260.42	243.13	226.29	196.22	171.64	151.77	135.69	122.49

TABLE 11 ISOMETRICS OF SUPERHEATED STEAM—SERIES II

T, deg. cent.	10.0	12.5	15.0	17.5	20.0
	Pressures in atmospheres				
310	....	....	....	....	92.03
320	....	....	....	103.79	95.76
330	....	....	117.97	108.15	99.36
340	....	135.22	123.20	112.35	102.84
350	156.26	141.70	128.22	116.41	106.30

TABLE 12 ISOMETRICS OF SUPERHEATED STEAM—SERIES III

T, deg. cent.	40.0	75.0	97.5	150.0
	Pressures in atmospheres			
200	....	....	....	13.214
210	....	....	....	13.585
220	....	....	20.504	13.945
230	....	26.490	21.096	14.295
240	....	27.296	21.677	14.640
250	....	28.086	22.247	14.979
260	....	28.855	22.805	15.316
270	49.829	29.604	23.353	15.650
260	51.505	30.340	23.893	15.982
290	53.094	31.066	24.425	16.311
300	54.636	31.779	24.951	16.638
310	56.139	32.480	25.472	16.963
320	57.611	33.172	25.988	17.288
330	59.064	33.853	26.500	17.611

cc. per gram. The equation is valid only for pressures not exceeding three atmospheres. It is of course empirical, but of the van der Waals type as far as the molecular model to which it can be referred. Incidentally the van der Waals or rigid molecule is definitely not sufficiently correct for general purposes, but the theory of the equation of state for a polar gas is so complex that it will not be advisable to use a more correct form of equation of state until a large body of *p-v-T* data is available. Meanwhile the saturation values computed by means of the equation of state from 125 deg. cent. to 0 deg. are believed to be substantially correct ($^1/_{10}$ of one per cent and possibly better).

It is gratifying to note the good agreement between the latent heats computed through the Clapeyron equation and the wonderfully consistent series of measurements made by Osborne, Stimson, and Fiock. It should be emphasized that the latter made actual measurements to about 270 deg. cent., and gave an empirical equation which the present authors have used to compute *extrapolated* values. Thus the values of latent heat appearing in all the tables above 270 deg. are not to be considered as direct experimental work (Table 5, for example, 3rd and 7th columns). Tables 10, 11, and 12 will probably be revised in the near future.

The data appearing in Tables 6, 7, 8-A, 9, and 9-A for saturated and compressed liquid have not heretofore been published. The values given appear to the authors to be final, although changes in the saturated-liquid volumes to the extent of a few parts per 10,000 may be required at higher temperatures when contemplated measurements in a new container are completed.

In conclusion, the authors express their relief at having finally found an alloy which permits a realization of the high accuracy of measurement of the pressure-volume-temperature relations which they have been endeavoring to attain. Already the temperatures of measurement have been advanced to 460 deg. cent., and it may be possible to go to even higher temperatures. In any event, a new year of research is entered upon with greater confidence than for some years. The fruit of the coming twelve months' activity, we believe, will be not only abundant but better than the earlier quality.

Experimental Data on the Properties of Steam

The volumes of all experimental apparatus were determined in terms of the density of mercury, assumed to be 13.5951 at zero degree centigrade and 1 atmosphere.

The atmosphere was evaluated from a knowledge of the acceleration of gravity at the place where the measurements were made, and is equivalent to the pressure exerted by 76 cm. of mercury at 0 deg. cent. for an acceleration of 980.665 dynes.

"Calories" in the accompanying tables were obtained by multiplying cc. per gram × atmos. by 0.024206:

$$V(\text{cc./g.}) \times p\ (\text{atmos.}) \times \frac{13.5951 \times 76 \times 980.665}{4.18605 \times 10^7} = V \times p \times 0.024206.$$

Some Additional Volume Data for Superheated Steam[1]

By L. B. SMITH[2] and F. G. KEYES,[3] CAMBRIDGE, MASS.

L. B. Smith

SOME provisional *p-v-t* values for superheated steam at specific volumes from 57.5 to 150.0 cubic centimeters per gram were presented in last year's report. The difficulties due to gas evolution in the steel bombs were discussed, and the apparent protective action of an oxide coating was pointed out.

Immediately following last year's meeting a new loading was made for measurements at about 30 cubic centimeters per gram. In computing the results of this run an appreciable falling off in pressure with time was detected. Every effort was made to find a leak, but without success, so it was necessary to conclude that some other influence was causing the drift in the measurements. A careful scrutiny of the data which had been presented in December demonstrated the same small drift. By plotting the pressures of duplicate measurements against time, it was found that suitable corrections could be applied to each individual observation.

In the case of the series measured at 57.5 and 30.0 cubic centimeters per gram, a considerable time elapsed after entering the bomb in the high-temperature bath and before making the first observation. This made it impossible to extrapolate the drift plot back to zero time, so the results of these measurements had to be discarded.

It now appears evident that the falling off in pressure was due to a slow oxidation of the steel by the steam. The fact that it was impossible to detect the presence of permanent gas in the system would indicate that the hydrogen was able to diffuse through the steel as rapidly as it was liberated by the oxidation reaction.

One more series of measurements was made in the steel bomb at 40 cubic centimeters per gram. The whole series was completed within a comparatively short period of time, and corrections made for the drift. However, it was not felt that an altogether satisfactory solution of the difficulty had been achieved, so it was decided to investigate the possibility of using some form of corrosion-resisting steel. As a result of this investigation, a bar of Nirosta-type stainless steel was obtained, and work was started on the construction of two spherical bombs.

Meanwhile some further measurements were undertaken on the compressibility of liquid water up to temperatures approaching the critical. There was used for this purpose a chrome-vanadium steel bomb that had been constructed some time ago to replace the original nickel high-pressure bomb. The results of these compressibility measurements will be found in the accompanying report of Dr. Keyes.[4]

During the summer the machine work on the stainless-steel bombs was completed, and the two pairs of hemispheres were welded up. This welding was done by the General Electric Company, making use of their atomic-hydrogen process.

The coefficients of expansion of the stainless steel and the volumes of the bombs were determined, and preparations were made to repeat certain of the runs at the larger specific volumes. The first run was not completed because of the rupture of a steel connecting tube. However, sufficient data were obtained to indicate that the steel was perfectly resistant to corrosion, as no drift in pressure could be observed.

---

[1] Contribution from the Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology, No. 255.

[2] Assistant Professor of Physico-Chemical Research, Massachusetts Institute of Technology. Dr. Smith received his B.S. in 1918, his M.S. in 1919, and his Ph.D. in 1923, all from Massachusetts Institute of Technology. He held, respectively, the Du Pont, Swett, and Savage Fellowships at M.I.T. from 1918 to 1921, and then became its research assistant and later research associate in physical chemistry.

[3] Director of Research, Laboratory of Physical Chemistry, Massachusetts Institute of Technology.

Contributed by the A.S.M.E. Special Research Committee on Thermal Properties of Steam and presented at the Annual Meeting, New York, December 1 to 5, 1930, of The American Society of Mechanical Engineers.

[4] Page 132.

TABLE 1 SUPERHEATED-STEAM MEASUREMENTS, CORRECTED FOR DRIFT
(Machinery-Steel Bomb)

Temp., deg. cent.	Specific volumes, cc. per gram: 40.0	75.0	97.5	150.0
	Pressures in atmospheres			
200	....	....	....	13.214
210	....	....	....	13.585
220	....	....	20.504	13.945
230	....	26.490	21.096	14.295
240	....	27.296	21.677	14.640
250	....	28.086	22.247	14.979
260	....	28.855	22.805	15.316
270	49.829	29.604	23.353	15.650
280	51.505	30.340	23.893	15.982
290	53.094	31.066	24.425	16.311
300	54.636	31.779	24.951	16.638
310	56.139	32.480	25.472	16.963
320	57.611	33.172	25.988	17.288
330	59.064	33.853	26.500	17.611

TABLE 2 SUPERHEATED-STEAM MEASUREMENTS
(Stainless-Steel Bomb)

Temp., deg. cent.	Specific volumes, cc. per gram: 20.0	30.0	40.0	50.0
	Pressures in atmospheres			
250	....	....	....	39.025
260	....	....	....	40.441
264	....	....	48.655	....
270	....	....	49.718	....
280	....	....	51.381	42.958
281	....	63.577	....	....
290	....	65.774	....	....
300	....	68.097	54.575	45.334
305	90.435	....	....	....
320	96.381	72.517	57.602	47.654
340	103.553	76.778	60.543	49.879
360	110.378	80.784	63.383	52.068
380	116.966	84.744	66.178	54.219
400	123.312	88.611	68.914	56.344
420	129.536	92.371	71.607	58.424
440	135.560	96.093	74.258	60.503
460	141.479	99.765	76.911	62.561

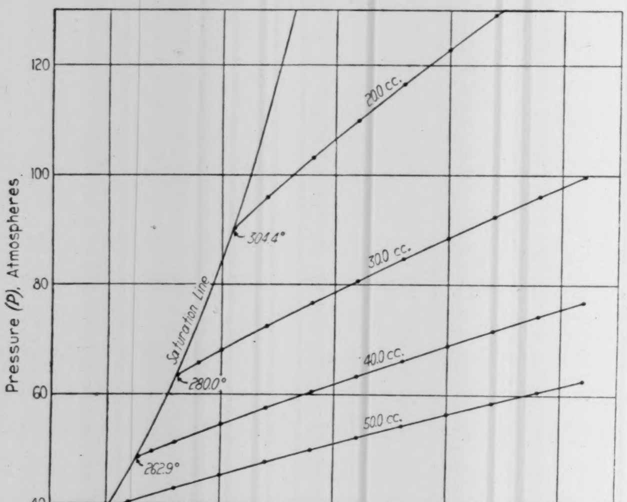


FIG. 1 RESULTS OF NEW SUPERHEATED-STEAM MEASUREMENTS AT SPECIFIC VOLUMES OF FROM 20 TO 50 CC. PER GRAM

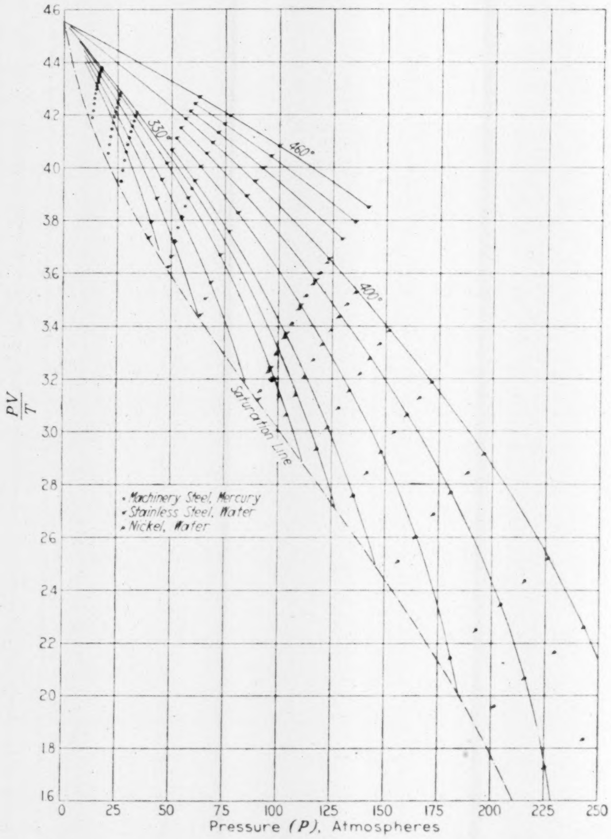


FIG. 2 RESULTS OF ALL THE M.I.T. MEASUREMENTS ON SUPERHEATED STEAM

At this time it seemed advisable to attempt measurements at higher temperatures than those attained in the previous work. The use of mercury as a confining fluid for the steam was of course impracticable due to its very large vapor pressure at high temperatures. It was therefore necessary to resort to the original method of confining the steam and transmitting its pressure with liquid water. This method has been thoroughly discussed in connection with the measurements in the original nickel bomb. A loading of pure, air-free water was made, and the four specific volumes of 50, 40, 30, and 20 cubic centimeters per gram were measured. The temperatures ranged from 250 deg. cent. to 460 deg. cent. (482 deg. fahr. to 860 deg. fahr.). Pressures ranged from about 39 atmospheres up to about 140 atmospheres. The stainless steel proved satisfactory from every point of view. Its perfect passivity toward the steam was indicated by the fact that measurements were entirely independent of time.

The results of the new measurements at specific volumes of from 20 to 50 cubic centimeters per gram are shown in Fig. 1. The four isometrics and the saturation curve are plotted together. The saturation temperatures for the different specific volumes are given by the intersections. It will be noted that observations were carried out at points quite close to the saturation condition, thus making it possible to determine the intersections with precision.

Fig. 2 shows the results of all the M.I.T. measurements on superheated steam. In this diagram pv/T is plotted against p. Each circle represents the results of one or more measurements. The solid lines are isotherms, and the broken line curving from left to right represents the saturation curve. The groups of circles curving upward and to the right each represent a constant volume.

At 20 cubic centimeters per gram there is a discrepancy amounting to between 0.5 per cent and 0.7 per cent between the old and new measurements. In seeking an explanation for this it was found that a redetermination of a small dead-space volume, preparatory to the latest measurements, had given a value differing from the older one by about 0.03 cubic centimeter. This difference in volume would largely account for the discrepancy in the reported pressures. At smaller specific volumes the difference would have a smaller percentage effect on the pressures. Thus the 5-cubic-centimeter-per-gram pressures as originally reported should not be in error by more than 0.2 per cent. The older measurements could perhaps most easily be corrected by assigning slightly larger values to the reported specific volumes. Before making such corrections it is desired to again redetermine the volume in question.

Plans for the immediate future include the construction of a new high-pressure bomb of stainless steel and a repetition of the measurements from 5 to 20 cubic centimeters per gram. These measurements will be extended to higher temperatures than was possible when using the nickel bomb. It is also planned to check the low-pressure measurements reported in this paper, using for this purpose the present stainless bombs, and to extend the observations out to a volume of 300 cubic centimeters per gram.

Report of Progress in Steam Research at the Bureau of Standards[1]

By N. S. Osborne,[2] Washington, D. C.

A GROUP of measurements of heat content of saturated water and steam covering the range of moderate temperature and pressure has been completed in accordance with the initial program undertaken. The results have been published in a detailed account[3] of this work, and were available for use in the choice of values for the International Skeleton Steam Table as revised at Berlin in June, 1930.

The scope of these completed measurements of heat content of saturated water and steam is from 0 deg. cent. up to 270 deg. cent., or up to a pressure of about 800 lb. per sq. in. It was intended to continue the measurements up to 300 deg. cent. (1200 lb. per sq. in.), using the same equipment, but this was prevented by the failure of a vital part of the calorimeter while working at 800 lb. pressure. This failure, apparently due to aging of one of the alloys used, interrupted progress in this higher range until the damage could be repaired or other apparatus made available.

Temporary emergency repairs have made it possible to continue use of the calorimeter at low pressures. A new series of measurements of latent heat has been completed in the region below the normal boiling point. These supplementary results are given in Table 1.

TABLE 1 LATENT HEATS BELOW 100 DEG. CENT.

Temp., deg. cent.	No. of expts.	Latent heat (Int. joules per gram)		
		B.S. experiments[1]	B.S. equation[2]	p-v-T relations[3]
50	10	2381.9	2381.6	2381.0
70	19	2333.3	2333.6	2333.3
90	7	2282.7	2283.4	2283.5

[1] Mean value from B.S. measurements.
[2] Value calculated by empirical equation:

$$L = 0.002562(374 - \theta)^2 - 5.883(374 - \theta) + 249.9(374 - \theta)^{1/3} - 113(374 - \theta)^{1/4}$$

[3] Calculated by Keyes (privately communicated), using the Clapeyron equation.

Comparisons of these observed values with the empirical equation previously derived from results at higher temperatures show that the equation is trustworthy down to 50 deg. cent. This experimental confirmation of the latent-heat formula is strengthened by close agreement with values calculated by the Clapeyron relation.

Meanwhile it became necessary to consider the course of future experimental work. It appeared that it would be possible by use of new equipment designed for the purpose to extend the range of the calorimetric measurements on saturated water and steam to still higher temperatures and pressures than those originally contemplated. Upon considering this possibility the advisory research committee of the A.S.M.E. recommended that this phase of the work be next undertaken to supply data now lacking in this important range.

---

[1] Publication approved by the Director of the U. S. Bureau of Standards of the Department of Commerce.

[2] Physicist, U. S. Bureau of Standards. Dr. Osborne was graduated from the Michigan College of Mines in 1899. He served the College of Mines for several years as instructor in mathematics and physics. In 1903 he entered the service of the Bureau of Standards, where his chief interest has been measurements of thermal properties of fluids, and where he is now in charge of the research being conducted on the properties of steam. In 1930 he was given the honorary degree of Doctor of Science by Stevens Institute of Technology in recognition of work on thermal properties of steam and ammonia. He was a delegate to the International Steam Table Conferences held in London in 1929 and in Berlin in 1930.

[3] Bureau of Standards Journal of Research, vol. 5, no. 2, August, 1930, p. 411, Research Paper No. 209. Trans. A.S.M.E., vol. 52 (1930), paper FSP-52-28.

Plans for equipment for this new project are now well under way These plans provide for the construction of a new calorimeter designed to be strong enough to safely withstand steam pressure up to the critical state. It is not, however, expected that all the types of calorimetric measurements upon the saturated fluid can be carried up to this limit. There are limitations on the execution and formulation of calorimetric measurements on the saturated fluid on approaching the critical state, and it is somewhat uncertain just how far up in the scale of temperature and pressure this method of measurement can be successfully utilized.

Although the general principles of operation of the new calorimeter will be similar to those employed in the previous equipment, a number of important changes will be made. These changes will adapt the design to the exacting demands of accurate calorimetry in the more severe temperature and pressure conditions now to be encountered, and will allow the vital parts to be kept more readily accessible for the detection and repair of faults.

For instance, the circulating pump in the calorimeter shell will be superseded by other means for distributing heat and for producing dry saturated vapor. This change will eliminate a shaft rotating in a packing at high pressure. The bath of circulated oil for thermal control of the calorimeter envelope and accessories will be abandoned, and in its place use will be made of isothermal guards made out of metal of high thermal conductivity, equipped with electric heaters so disposed as to provide energy where it is needed to compensate heat loss to the surroundings. These new features in design will eliminate a number of complicated and delicate mechanical parts, also the troubles, hazards, and unreliability of the oil, and will make construction, assembly, and repairs simpler.

Choice of material for the calorimeter shell itself and for other parts required to retain high strength at high temperatures has been made easier by recent metallurgical research, and a material has been obtained which is believed to have suitable properties. This material is an iron alloy containing about 20 per cent chromium, 8 per cent nickel, and 4.5 per cent tungsten. Tests of this metal to determine its behavior when stressed at high temperatures show that it is very resistant to creep at the temperatures to be experienced. It is not an easy material to work, but with care it can be machined successfully. Work on this vital part of the apparatus is now in progress.

The technique of calorimetry in this field is yet to be developed, and consequently each stage in the construction and assembly is somewhat tentative, depending on results of proof tests. This is particularly true in the development of valves, which must function so perfectly in the control of the fluid as not to cause error in accounting for the amount of fluid or energy. The control valves will probably be the most delicate and capricious parts of the apparatus, which is a reason for seeking simplicity of design to afford ready accessibility of these parts.

Much of the auxiliary equipment which has been assembled for the project just completed can be used in this new work, and the experience already gained is a valuable guide in solving the new problems which arise on extending the work into a more formidable region.

The Science Museum, London

IF THE industries of the country could issue so eminently satisfactory a report as that of the Science Museum, in which those industries are so admirably illustrated, there would be little room for any misgivings. From a total of half a million in 1920 the number of visitors had grown to over a million in 1929, while during the same period the housing, display, and extent of the collections had been improved out of recognition. While it would be easy to place too much significance on the mere question of attendances, too much can hardly be said for the increase in the value of the museum to the student, the teacher, and the technical man. In the teaching of a scientific subject there is no better way of approaching it than with a study of its history, and we can conceive no more fascinating introduction to any branch of engineering than a few hours spent in the Science Museum under proper guidance. Whether it be the history of units and standards, of surveying and construction, of tools and machines, of mining or of power engineering, in the Science Museum are to be seen the apparatus and appliances used by pioneers, in some cases the apparatus being that actually made and used by the investigator or inventor himself. Kelvin once said that "Joule's discovery of the mechanical equivalent is the greatest reform physical science has experienced since the time of Newton," and here in the Science Museum is Joule's paddle apparatus for heating water by stirring it. Of such treasures the Museum has many, and a catalog of them would be eloquent of the contributions of our countrymen to science. But it is not only in the possession of such historic appliances that the Museum is rich, for its aim is to illustrate the present as well as the past, and among the list of donors in the latest report are such names as Armstrong-Whitworth, Chance, Ferranti, Lanchester, and Rolls-Royce. Remembering the vast development of physical science and engineering of recent years, we are not surprised to learn that the collections have outgrown the buildings, and that the provision of further accommodation is absolutely necessary if the Museum is to keep its leading position among such institutions.—*Engineering*, Dec. 12, 1930, p. 749.

Progress in Oil Refining

A Review of the Past Year's Developments of Interest to Mechanical Engineers

IN REFINING, a similar program to that in production of crude to fit the demand had to be carried out in some measure. As a result, the refiners found themselves equipped for greater capacity than called for, particularly in cracking stills, and therefore their general purpose in adding to equipment in 1930 was to realize savings that could be accomplished only by eliminating obsolescent equipment. In some cases, of course, the new equipment reported as going into operation was planned and started during 1929.

The effort of the industry to control its output to meet the demands of general business and of the individual who is mainly interested in gasoline and motor oil is based not on obtaining a maintained price for the product, but on avoiding an actual loss. It is also along the lines of conservation of a natural resource, which alone justifies such curtailment.

Advances in Crude Fractionating Equipment

The general tendency in crude fractionating equipment is toward larger units, and at the same time to obtain equal or better fractionated products of predetermined characteristics, and with a greater degree of automatic control.

As an extreme example, an atmospheric fractionating tower, 11 ft. 6 in. in diameter by 155 ft. high, containing 75 trays, in which eight side streams besides bottoms and overheads are produced, and running 7500 bbl. per day of crude, indicates the desire to accomplish in one operation what formerly required two or more.

Combination atmospheric and vacuum units of 14,000 bbl. daily capacity, and a number of 10,000 bbl. daily capacity, have been built.

A large vacuum fractionating tower, 21 ft. in diameter and approximately 115 ft. high, is handling about 10,000 bbl. daily of reduced Midcontinent crude.

In cracking, the well-known Dubbs process is claimed to be in use in over 250 units, the capacity varying with the type of operation and charging stock.

During the past year six 3000-bbl. Holmes-Manley units were completed at Port Arthur, as well as several 10,000-bbl. cracking pipe stills in California.

There has also been considerable development in DeFlorez stills, six additional being under construction, for 1000 bbl. of distillate each, which will go into operation early in 1931.

Incidentally, several stills of 11,000 to 15,000 bbl. capacity, either as viscosity breakers or rerun stills, are being built abroad by American companies.

Practically all of the above-mentioned units involve the use of the serpentine pipe heater, consisting of straight tubes and headers, and a tendency toward free-flow headers is very marked. The use of centrifugal charging pumps on the mixture of recycle oil and fresh stock, which is common to the cracking heaters, is gaining headway over reciprocating pumps with some refiners, although several large reciprocating pumps of the engine-driven flywheel type have been installed in the Midcontinent district.

In the construction of towers, the fusion-welding processes are gaining favor. One company reports the largest vessels installed during 1930 as being 8 ft. in inside diameter by 38 ft. 2 in. long, with $4^{1}/_{2}$ in. wall thickness (includes 1 in. for corrosion). They are being operated at 400 lb. per sq. in. pressure and at a temperature of 900 deg. fahr.

Another company is installing both evaporators and bubble towers of shells spun from pierced billets. In their final shape rings for evaporators are 9 ft. in inside diameter, $1^{3}/_{4}$ in. in minimum thickness, and 8 ft. long, and are made up into towers 32 ft. long with the use of elliptical heads and fusion-welded girth seams. After all welding is finished, the entire tower is placed in an annealing furnace. The rings for the bubble towers are spun to a $1^{1}/_{4}$-in. nominal thickness, 8 ft. inside diameter, and the tower is made with elliptical heads to a length of 51 ft. The girth seams on the bubble towers are made with finished seamless-ring butt straps, shrunk over finished ends of spun rings, double riveted and calked by electric welding. Both sets of these towers will operate nominally at 200 lb. pressure to a maximum temperature of 1000 deg. fahr. in evaporators and 750 deg. fahr. in bubble towers.

The makers of the Gyro vapor-phase cracking process report 29 units in operation with a total rated capacity of 19,200 bbl. per day of gas-oil charging stock, of which eight units, with a total capacity of 5500 bbl. per day, were completed during the past year. They have under construction five additional units with a total capacity of 5000 bbl. per day in which material changes in design have been made, enabling the operator to handle from 40 to 50 per cent more charging stock than indicated by rated capacities.

In connection with this type of unit, gasoline is manufactured from the gases produced by means of compression to approximately 1000 lb. per sq. in. and an exothermic process by which approximately five gallons of gasoline are recovered from each 1000 cu. ft. of gas processed.

The outstanding development in refining this year has been the completion and commercial operation of the hydrogenation plant of the Standard Oil Company of New Jersey at their Bayway refinery. Numerous articles have been published in the trade journals, and it is assumed that the conditions of operation are

---

[1] Compiled by Walter Samans, Chief Engineer, The Atlantic Refining Company, Philadelphia, Pa. Mem. A.S.M.E.

therefore fairly well known. The major adaptations, as noted by a paper presented before the American Chemical Society, are:

1 The conversion of heavy, high-sulphur, asphaltic crude oils and refinery residues into gasoline and distillates low in sulphur and free from asphalt, without concurrent formation of coke.

2 The alteration of low-grade lubricating distillates to obtain high yields of lubricating oils of premium quality as to temperature-viscosity relationship, Conradson carbon, flash, and gravity.

3 The conversion of off-color, inferior burning-oil distillates or light gas oils into high-gravity, low-sulphur, water-white burning oils of excellent burning characteristics, with gasoline being the only other product except for a slight gas formation.

4 The desulphurization and color and gum stabilization of high-sulphur, badly gumming cracked naphthas.

5 The conversion of paraffinic gas oils into low-sulphur, gum- and color-stable, good anti-knock gasolines without the production of coke or tar.

It is not claimed by any one connected with this process that it will immediately revolutionize manufacturing methods in the industry, but it indicates more possibilities for the future than any of the known cracking processes.

There are still technical difficulties to be overcome before the process can be widely used, and obtainable production of crude has to be somewhat reduced before the hydrogenation process will have wide commercial application.[2]

Besides the production of better lubricants expected with the hydrogenation process, we have the continued use of the Edeleanu process, in which extraction of oils with sulphur dioxide furnishes a product of better viscosity-temperature characteristics.

There are at the present time ten Edeleanu plants in operation in the United States, some of these being both for lubricating oils and kerosene. Five lubricating plants have a total capacity of 6300 bbl. per day, and eight kerosene plants have a capacity of close to 23,000 bbl. per day, varying from 875 to 6300 bbl. capacity per plant.

MOTOR GASOLINE[3]

As regards motor gasoline, competition, as well as the high-compression automotive engines, has forced refiners to produce practically a premium fuel with improved anti-knock quality. Considerable progress has been made during the past year in the standardization of knock-testing engines. About 65 engines of one make alone are now in use, and it may be adopted as both an American and a British standard.

Anti-knock values of motor gasolines have in the past been rated on the rather indefinite scale of "Benzol Equivalent." This has been superseded by the "Octane Number," which is a perfectly definite and reproducible index. This number is defined as the percentage of iso-octane in a mixture of normal heptane and iso-octane, which mixture equals the unknown fuel in anti-knock quality. The higher the octane number, the better the anti-knock quality of the fuel.

In various cracking processes in vogue, producing what is known as pressure distillate, which is in fact a form of motor gasoline in a crude state, it is becoming more apparent that stabilization of this distillate is imperative. Gasoline has been gradually getting more volatile, but due to the danger of vapor-lock troubles, this trend particularly as it concerns the very light hydrocarbons, is limited. Stabilization will permit removal of these light hydrocarbons, while allowing somewhat heavier gaseous hydrocarbons, as well as pentane to remain in the finished gasoline.

ABSORPTION AND STABILIZATION IN GASOLINE RECOVERY[4]

During the past year about twenty refineries have taken steps to improve the efficiency of their vapor-recovery plants. In practically every case, high butane extraction has been provided for. In at least two plants operating on gases from vapor-phase cracking units, provision has been made for the extraction of propane and propylene up to 80 per cent of the gas content.

The well-known conventional absorption process is fundamentally the same, but many changes in the flow and the equipment have been developed to make possible the improved extraction efficiency. Absorber pressures have in general been increased. Most of the newer plants operate at pressures in excess of 250 lb. Practically all of the 1930 plants use light absorption oil. Both of these changes and the use of efficient bubble-type absorbers have resulted in greatly increased oil saturations, with correspondingly increased temperature rises in absorbers. Several of the newer installations have been equipped with intercoolers in absorbers to meet this condition.

Increased absorption of butane and propane has of course led to greatly increased absorption of methane and ethane. These fixed gases have received much attention in the past year. Former practice was to recompress the vent gases from the condenser to recover the gasoline constituents.

The use of compression plants feeding either directly or through coolers into stabilizing units has increased somewhat during the year. This system seems to have established its economy in special cases where butane extraction need not be high, where the methane content is low, and where power for compressing is cheap.

Considering present business conditions, it is notable that the petroleum industry has more than ever been required to develop improved processes to help maintain its economic balance. While all general lines of industry are more or less dependent upon it, the natural result of restricted use has brought about the keenest competition.

---

[2] See "Aspects of Hydrogenation in Refining," by R. T. Haslam and R. P. Russell, *The Oil & Gas Journal*, Nov. 27, 1930.

[3] The general technical statements made, particularly as to motor gasoline, were contributed by Dr. J. B. Hill, The Atlantic Refining Co.

[4] Contributed by G. M. Jackson, Tulsa, Okla.

Survey of Engineering Progress

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS (See also Internal-Combustion Engineering)

The D'Ascanio Helicopter

THE D'Ascanio helicopter, which is still in the experimental stage, has already accomplished several successful flights at the Ciampino Nord Aerodrome, both in the open and inside the airship hangar there. It consists of a cruciform-framework fuselage surmounted in the center by two large horizontal "propellers," rotating in opposite directions. The blades of these "propellers" take the form of airfoils, complete with tail elevator (at the outer tip), and jointed at the roots, so that they are free to take up, automatically, any angle of incidence determined by the tail elevators.

Thus, by operating the tail elevators the pilot can vary the angle of the blades, thereby controlling the ascent and descent of the machine. The propellers, it may be mentioned, are used as "parachutes" should the engine cease to function.

Horizontal flight is obtained by inclining the machine in the direction one wishes to take, which is achieved by means of small horizontal propellers mounted on the fuselage extremities.

The machine is a single-seater, weighs about 800 kg. (1764 lb.), and is fitted with a 95-hp. Fiat A.50 S. engine. During the tests at the Ciampino Aerodrome, the machine took off from and landed in the same space, a circle of only 15 m. (49 ft.) diameter, and maintained a steady, hovering flight at an altitude of over 4 m. (13 ft.) for a considerable period. Then, at a given signal, the machine descended and effected a safe landing. It subsequently flew in a closed circuit of 1 km., and from one end of the aerodrome to the other, thus securing a world's record (for helicopters) for distance in a straight line.

The endurance record was also secured with a flight of 8 min. $45^{1}/_{2}$ sec., while the record for altitude was obtained with a height of 18 m. (59 ft.).

This helicopter also carried out further demonstration flights inside the airship hangar, where in spite of disturbing air eddies, produced by the presence of the hangar walls, the machine performed evolutions in all directions, remaining aloft for several minutes. During some of the tests the pilot let go of all controls, and the machine remained perfectly steady.

Up to the present, the flights carried out with this helicopter have been made only to demonstrate the soundness of the principle, and with the valuable data thus collected the designer states that the next machine will be able to demonstrate its practical use. (*Flight*, vol. 22, no. 46/1142, Nov. 14, 1930, p. 1249, 1 fig., *dA*)

The Autogyro

THIS is a paper by J. de la Cierva, who presented a previous one on the same subject before the same society in 1925, and intended primarily to show the progress made in developing this type of aircraft.

The autogyros recently produced have no better performance than the equivalent conventional airplanes. In fact, they have a little less speed and a little less climb than the best equivalent airplanes. Nevertheless, they are better flying machines. If they fall a little short of the best airplanes in that rather vague quality which is called "performance," they have a performance of their own, which is utility and safety.

The comparison in performance between existing autogyros of several types and the best equivalent airplanes can be summed up as follows: Top speed, 5 to 10 per cent less; rate of climb, 20 per cent less; minimum horizontal speed, 50 per cent less. The take-off since the introduction of the deflector tail is better. The landing qualities are so well known that it is hardly necessary to mention them. In any case, the author states that the latent type of autogyro can, with proper handling, be landed in perfectly still air with no run at all after touching the ground. In a steep descent of about 45 deg. the vertical speed of the latest machines is not more than 12 to 13 ft. per sec.

The latest autogyros have an appearance rather different from those of 1925. They are no longer transformed airplanes; and the fuselage, undercarriage, and tail have been gradually transformed to suit better the necessities of the new system. The undercarriage is wider, the fuselage shorter, and the tail is of a peculiar design. Also the ailerons, which in 1925 were fixed on a transverse beam or stick, are now supported by small fixed wings, such as the bottom plane of a sesquiplane.

The rotary wings are of a different shape and construction. Their main characteristics are the smoothness of the skin, the local strength of the same to prevent deformation under very high unit loads, and the considerable flexibility of the whole blade in a plane perpendicular to that of rotation.

The blades are hinged to a central hub as in the old machines, so as to allow free flapping in flight. A secondary hinge perpendicular to the first is also provided, allowing a certain freedom between two consecutive blades. Those two articulations give, by the way, the maximum degree of freedom that rotary wings can have without becoming unstable with respect to the axis of rotation in horizontal motion.

In these machines the tail acts as self-starter to the rotary blades prior to take-off. The slipstream of the propeller is deflected upward and the rotary blades are forced in turn to a flapping movement which is transformed by aerodynamical action into circular motion. From sixty to seventy per cent of the flying revolutions are obtained in no wind by this means, and take-off is possible as soon as the horizontal speed corresponding to the position of the machine on the ground is attained.

In comparing the autogyro with the airplane, the fact that the former has an inferior lift-on-drag ratio is often put forward as proof of its inefficiency. In reality, what happens is that the airplane and the autogyro are respectively most efficient under different conditions. The airplane, or at least an airplane of normal proportions, has a maximum efficiency in its middle range of speed, while the autogyro is at its best at both ends. It is perfectly possible for an autogyro to be faster than an equivalent airplane, though its optimum lift-on-drag ratio would be inferior. It can be shown that if the diameter of the autogyro equals the span of the airplane, and both machines have the same parasite drag, the induced and parasite power would be the same in either case, and the required horsepower equations would differ only in the term corresponding to profile drag. In the airplane this term will be practically proportional to the cube of the speed, while in the autogyro it would only be directly proportional to the speed within wide limits. This proves that the greater the speed the less the difference there is between both machines, and that eventually the autogyro must become the faster.

A definite advantage of the autogyro as compared to the airplane is its extraordinary aerodynamical flexibility and adaptability. In an airplane the load per square foot of wing area defines its landing qualities, and if the power is increased, in order to obtain the full benefit, an increase in wing loading must follow, with a corresponding increase in the landing speed. Roughly speaking, the landing speed of an airplane is proportional to its top speed. In an autogyro the landing qualities depend almost exclusively on the load per square foot of disk area, while in order to obtain the best possible efficiency at top speed it is only necessary to keep the ratio of tip speed to top speed equal to about 1.5, which ratio depends only on actual blade area, assuming the pitch constant. This means that, within wide limits, autogyros can be designed to have different top speeds, but exactly the same qualities in landing and descent. Of course, a limit must come when the blades, even reduced to three in number (two blades only have been tested in flight and found impossibly rough), will become too narrow and thin, but beyond that limit a decrease in pitch angle can still be used to increase the rotational speed with only a slight decrease in efficiency at slower speeds—not very important in machines with a considerable excess of power. It will probably be possible to go beyond the new limit by using for the rotary blades airfoil sections with a less abrupt stalling than the Göttingen 429, stalling that when produced on a considerable portion of the retreating blade at low tip speed to advancing speed ratios means a sudden drop in the tip speed to top speed efficiency. The author thinks it is very probable that ratios of about one will be used in very fast autogyros in the future. (J. de la Cierva in *Journal of the Royal Aeronautical Society*, vol. 34, no. 239, Nov., 1930, original paper pp. 902–911, 4 figs., discussion pp. 911–919 and reply to discussion, 919–921, *dgA*)

ENGINEERING MATERIALS

Beryllium

ACCORDING to engineers of the Beryllium Development Corporation of America, beryllium deposits have been found in the pegmatite dykes of the Winnipeg River area, Canada, over 500 square miles in extent. The deposits are said to be of a massive character. (*Steel*, vol. 87, no. 26, Dec. 25, 1930, *g*)

FORGING

Precision Forging

PRECISION forging was frankly developed to create more business for a drop shop equipped with a liberal supply of hammers but located in a section which places it at a handicap with reference to the center of drop-forging requirements, which is the automotive market of Detroit. The idea is to make the forgings so closely to dimensions that a share of machining costs is thereby avoided. The cost of the forging operation is of course higher, but the net result is reported to produce a considerable saving. There can be, therefore, no set rules for the manufacture of precision forgings to meet each job having to be handled as such.

The development of the new art required some experimenting, in the course of which it became evident among other things that to meet the close tolerances which were set, new tolerances of drop-hammer quality had to be considered. Drop hammers had to be built to provide greater speed so that the forging could be completed within the narrowest heat range, and generally had to be better built.

It is evident that the close tolerances in forging heretofore regarded as merely laboratory demonstrations are entirely practical in volume production.

From present appearances, it is reasonable to say that the next two or three years will result in probably greater improvement in drop-forging quality and possibilities than has taken place in the last two decades. While the outstanding thought during the last period was how to cut the cost while maintaining quality, the next step in drop forging is undoubtedly going to be how to make a better forging, which will materially lower machining costs and thus make for a saving in the finished product. It is interesting to speculate on what will be accomplished the next few years when well-established drop-forge shops will vie for closer tolerances and better finish.

The article describes in particular the practice of the Billings & Spencer Co. of Hartford, Conn., where the process was developed. (A. H. Dante, Gen. Mgr., Billings & Spencer Co., Hartford, Conn., in *The Iron Age*, vol. 126, no. 25, Dec. 18, 1930, pp. 1840–1841 and 1902, illustrated, *d*)

INTERNAL-COMBUSTION ENGINEERING

The Clerget Aircraft Diesel Engine

THIS is an air-cooled engine with radially disposed cylinders and a rating of 100 hp. at 1900 r.p.m., and comprises nine cylinders of 4.72 in. bore by 5.12 in. stroke. Its weight is 462 lb. A 200-hp. engine has been completed with the same number of cylinders but of larger bore and stroke.

One of the features of this engine is a decompression and oil-drain valve. When getting ready to start the engine, all of the exhaust valves are raised off their seats simultaneously by the pilot by means of a suitable mechanism. The exhaust valves are not located in the same position in all of the cylinders, each being at the lowest part of the compression chamber, so that when they are raised, any oil which may have accumulated in the compression chamber (and which, on account of the high compression ratio used, might influence the volume of that chamber materially) is drained off. Decompression, of course, also facilitates starting, which is effected by means of a rubber-cord portable starter. The engine is stopped by pressing on the "decompressor," thereby lifting the exhaust valves off their seats.

A separate injection pump is provided for each cylinder. The pumps are located in the crankcase parallel with the respective cylinders. Fuel is conducted from the pump to the injection valve through an outside tube of soft copper of such dimensions that it will stand pressures up to 14,000 lb. per sq. in. If, however, higher pressures are attained, the tube will burst and thus protect more important parts. All of the pumps are operated by a single cam which is mounted on a helical spline on the crankshaft so that the time of injection can be varied by shifting it in the axial direction. The cam does not contact directly with the pump plungers but works through tappets. The pump plungers each have a segment-shaped foot so that they can be acted on properly by the tappets, although the latter is shifted angularly for injection timing.

The fuel employed for this engine is gas oil and the specific consumption is claimed to be 0.44 lb. per hp-hr. The original article describes in detail the fuel-injection pump. (*Automotive Industries*, vol. 63, no. 22, Nov. 29, 1930, pp. 784–786, 4 figs., *d*)

MACHINE DESIGN

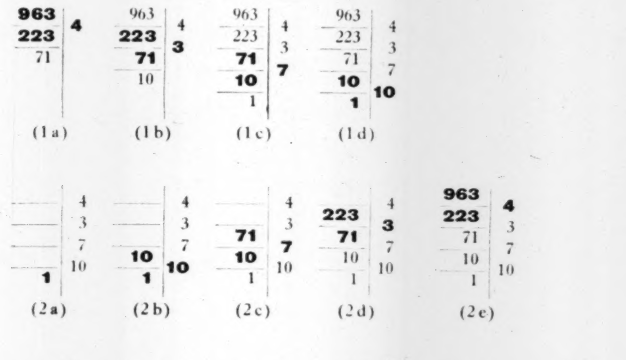
A Method for the Correct Determination of Change Gears for Difficult Transmission Ratios

The method which is described in the article here abstracted is said to be suitable where an unusually high degree of precision is required. Details are given in the following example.

Example. Design two gears to provide a speed ratio for their shafts of 963:223. In this case 223 is a primary number, while 963 contains the primary number 107 as a factor. It is necessary to replace these numbers by smaller numbers which can be used for fixing the number of gear teeth to be used. As a first approximation we might replace the ratio 963:223 by 962:222 = 13:3. Actually, however, it will be shown that a very much higher degree of approximation is possible.

TABLE 1 METHOD OF DETERMINING DIFFICULT GEAR RATIOS

(*Gegenüber* = as compared with; *gegeben* = given. This figure has been reproduced from the original German article, and it should be noted that in the decimal fractions given commas are used in place of decimal points or periods.)


963 223 71 | 4
963 223 71 10 | 4 3
963 223 71 10 1 | 4 3 7
963 223 71 10 1 | 4 3 7 10
(1a) (1b) (1c) (1d)
1 | 4 3 7 10
10 1 | 4 3 7 10
71 10 1 | 4 3 7 10
223 71 10 1 | 4 3 7 10
963 223 71 10 1 | 4 3 7 10
(2a) (2b) (2c) (2d) (2e)
4 3 7 [10]
7 1 | 4 3 7
22 7 1 | 4 3 7
95 22 7 1 | 4 3 7
4 3 [7] [10]
13 3 1 | 4 3
(3a) (3b) (3c) (3d) (3e) (3f)
4 · 7 · 31 / 3 · 67 0,0009 %
11 · 53 / 27 · 5 0,003 %
2 · 23 · 23 / 5 · 7 · 7 0,0004 %
16 · 3 · 13 / 17 · 17 0,0007 %
2 · 41 / 19 0,06 %
4 · 3 · 3 · 3 / 5 · 5 0,04 %
868 201 64 9 1 | 4 3 7 9[10]
583 135 43 6 1 | 4 3 7 6[10]
1058 245 78 11 1 | 4 3 7 11[10]
1248 289 92 13 1 | 4 3 7 13[10]
82 19 6 1 | 4 3 6[7[
108 25 8 1 | 4 3 8]7[
(4a) (4b) (4c) (4d) (4e) (4f)
14921 10000 4921 158 23 20 3 2 1 | 1 2 31 6 1 6 1 2
[20] [3] [2] [1] | [6] [1] [2]
661 443 218 7 1 1 | 1 2 31 6 1
567 380 187 6 1 | 1 2 31 6
567/380 = (3 · 3 · 3) · (3 · 7) / (2 · 2 · 5) · 19 · 2/2 = 27 · 42 / 20 · 38
=1,4921 05 gegenüber: 1,4921 (gegeben)
(5a) (5b) (5c) (5d) (5e)

Rule 1—"Building Down." The procedure is essentially that indicated by steps in Table 1.

Referring to (1a) in Table 1, we divide the larger number 963 by the smaller number 223, which gives 4 with a remainder of 71. The quotient 4 is written to the right of the vertical rule and the remainder 71 under 223. The same operation is repeated, 223 being divided by 71 (the black figures in the next column (lb)). This gives a quotient of 3 and a remainder of 10. Then further divisions such as (*c*) and (*d*) are carried out in succeeding columns until there is no remainder.

As far as the operation of this process is concerned, the only things of interest for further use are the quotients 4, 3, 7, and 10. As shown in the next horizontal series (2a), (2b), etc., by means of these quotients the original numbers 963 and 223 can be reconstructed by working backward.

Rule 2—"Building Up." As shown in the second row at (2a), the figure 1 is written at the left-hand side under the bottom rule. In the next column (2b) this is multiplied by 10, which is the final quotient in the preceding series. In column (2c) 10 is multiplied by 7 and the 1 of the remainder is added, which gives 71. Next 71 is multiplied by 3 and 10 added, which gives 223. Then 223 is multiplied by 4 and 71 added, which gives 963.

The next two rules are intended to give the "approximative values," and in particular Rule 3 gives the "main approximative values" which depart from the true values in what might be called large steps, while Rule 4 makes possible a finer differentiation by means of "intermediate numbers."

Rule 3—"Main Approximative Numbers." Referring to (3a), we obtain the first approximative number by eliminating the last quotient 10 from row 1, and by starting to build up in accordance with Rule 2 from the quotient 7 just preceding the last. [See (3b) and (3d).]

The next approximative number is obtained by eliminating the quotient 7 and proceeding in the same manner as before [(3e), (3f), etc.].

In the first case [column (3d)] we obtain the first approximative value for the gear ratio, namely, 95:22 (equal to 4.318182), which differs from the true value 963 : 223 (equal to 4.318368) by only 0.004 per cent. As the next approximative value [column (3f)] we obtain 13:3 (= 4.3333), which differs from the true value by 0.35 per cent, and in the last approximation 4:1 the difference is as great as 7.5 per cent. These main approximative values are obtained in accordance with Rule 3 by a stepwise elimination of the last quotients. As more quotients are eliminated they move further and further away from the true values, but the numerator and denominator become smaller, and furthermore there can be no pair of smaller numbers which would be as near (or nearer to) the true values as the given numbers. The numerator and denominator of all approximative values are always prime numbers with respect to each other, and therefore represent ratios which cannot be simplified.

In very many cases the application of the rules given above is sufficient. Sometimes, however, either the denominator or the numerator of the approximative value so found is a prime number, which makes the approximative value unsuitable for the present purpose because it cannot be factored.

In such cases, in order not to have to go to the next approximative number, which gives a far lower degree of precision, resort is had to Rule 4.

Rule 4—"Intermediate Approximative Numbers." Instead of eliminating the quotient completely it is replaced by a number of nearly the same value, whereupon the "building up" in accordance with Rule 2 is undertaken. Thus, the final quotient 10 may be reduced to 9.8 or increased to 11.2 [columns (4a)–(4d)]. Or the immediately preceding quotient 7, instead of being struck out as recommended in Rule 3, can be replaced by, say, 6.5 or 8.9 [columns (4e) and (4f)]. In this way a number of approximative values are obtained which gradually approach nearer and nearer to the true value, and which are always nearer

to it than those obtained when the respective quotients have been completely struck out. It should be pointed out, however, that the lowering of the values of the respective coefficients should not be carried too far (certainly not more than one-half of the coefficient to be replaced), as otherwise the deviations become too great. Increase in the value of the quotient also undesirably affects the value of the fraction, but less rapidly than decrease. On the other hand, it results in larger numbers of teeth.

The percentage deviations from true values for columns (4 a) to (4 f) are noted above each number. In addition to this the factoring of the approximative values found into similar factors is given, and it is to be noted that in position (4 c) (obtained through substitution of 11 or quotient 10) an approximative value of 1058:245 is given, which can be well represented by toothed gears and differs from the true value of 963:223 by only $^4/_{1,000,000}$, which is far more accurate than anything that can be done either with a slide rule or a table of logarithms. Because of lack of space a second example in the original article cannot be given here. (Eng. Erich Zscherpe, Berlin. *Automobiltechnische Zeitschrift*, vol. 33, no. 33, Nov. 30, 1930, pp. 797–798, *pA*)

MECHANICS

A New Theory of Epicycloidal Trains of Gears and of Relative Movements

THIS is an extensive article and only an abstract can be presented here. From the text it would appear that when two epicycloidal mechanisms give the same ratio of speed by an immobilization of one of the members, no matter which it is, they necessarily give the same speed ratios by the immobilization of any one of the other members, or a total of six speed ratios. The character of connection between the parts matters little.

In order to obtain the given ratio of speed, there are always two other families of epicycloidal solutions in addition to the one which gives the desired speed ratio directly. In the relative calculation of epicycloidal trains the investigation may be limited to the case of a non-epicycloidal movement of the mechanism under consideration, and in order to pass to epicycloidal operation the investigation may be supplemented by an elementary transformation of the terms of a fraction.

A graphical method has been developed by the author which makes it possible to control the calculations and also to settle the way in which the calculation should be made in order to obtain the desired result. The analytical and graphical methods are applicable to the calculation of relative velocities of rotation of any three mobile elements, as well as of continuous or discontinuous rotations taking place within the same time.

The following abstract is a mathematical presentation of the new theory.

The author starts by establishing what he calls a Law of Recurrence, which he formulates as follows:

If we designate by *a*, *b*, *c* the angular velocities of three mobile elements *A*, *B*, *C* connected mechanically, and, in particular, of three members of an epicycloidal train, and if we know the algebraic value *K* of the ratio a/b when *C* is stationary, i.e.,

$$\frac{a}{b} = K \qquad [1]$$

then we can write directly the value of the ratio b/c corresponding to the case when *A* is held rigid by transforming the value of *K* into the value $1 - (1/K)$. The same applies to the value of c/a, and hence for *A* fixed we have

$$\frac{b}{c} = 1 - \frac{1}{K} \qquad [2]$$

This rule permits us to limit all calculations to those relating to a non-epicycloidal system, the rest being done automatically without any special reasoning and risk of error, provided we are considering the operation of an epicycloidal train of which we know the geometric elements or provided we are seeking for the geometric elements which in epicycloidal operation would give the desired result.

The Law of Recurrence is a sort of rotative permutation connecting the denominator of one fraction with the numerator of the next one.

Case Where the Three Elements Are Movable. The Law of Recurrence stated above permits us also to write directly the three equivalent expressions which give the relations between the simultaneous velocities *a*, *b*, *c* of the parts under consideration.

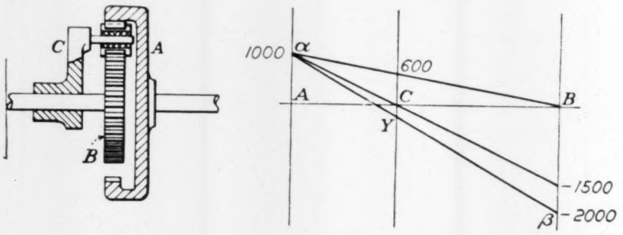


FIG. 1 GRAPH FOR SOLUTION OF EPICYCLOIDAL GEAR TRAINS

$$\frac{a - c}{b - c} = K \qquad [1]$$

$$\frac{b - a}{c - a} = 1 - \frac{1}{K} = K \qquad [2]$$

$$\frac{c - b}{a - b} = 1 - \frac{1}{K} \qquad [3]$$

Graphical Method. On an indefinite straight line we mark the points representing the part *A*, *B*, *C*, starting, for example, from the value $a/b = K$ corresponding to the case where *C* is held rigid, so that

$$\frac{AC}{BC} = \frac{a}{b} = K \qquad [A]$$

The segments *AC* and *BC* have to be computed both as to magnitude and to direction.

All straight lines in space cut the perpendiculars erected on *A*, *B*, *C* at points α, β, γ, the ordinates of which on the same scale represent in magnitude and direction the conjugated possible velocities of the train under consideration. In particular, if the straight lines pass through one of the points *A*, *B*, *C* we have the ratio of velocities of the other members when this element is held rigid.

Example. In the case of Fig. 1 the following equation holds good.

$$\frac{AC}{BC} = K = \frac{2}{3} \qquad [B]$$

Let us assume that *A* revolves constantly at 1000 r.p.m. We can then read directly from the graphs in r.p.m. on a metric scale

$$\alpha = 1000 \text{ r.p.m.} \left| \begin{array}{ll} c = 0 & b = -1500 \\ b = 0 & c = +\,600 \\ b = 2000 & c = -\,200 \end{array} \right.$$

The precision of the reading depends of course on the scale adopted, but in any event the direction and order of magnitude of the quantity desired are clearly in evidence, while the calculation gives a very precise value.

At the conclusion of the article the author points out that it is rather strange that epicycloidal trains which permit an extremely wide variation of combinations of velocities and which are very flexible mechanisms giving excellent solutions of numerous mechanical problems, are used comparatively seldom. He believes that the only reason for it is that their calculation is a delicate matter subject to errors, which leads the majority of designers to avoid their use. (Pol Raveneaux in *Technique Automobile et Aerienne*, vol. 21, no. 151, 4th quarter, 1930, pp. 97–106, 24 figs., *mt*)

MOTOR-CAR ENGINEERING

Troubles in the Motor-Car Industry in Germany

THE interest of the original article lies in the fact that apparently, at least in some respects, the motor-car manufacturers in Germany are facing a situation not unlike that of their brethren in the United States. The industry is threatened from two different directions. In the first place, the State Railways want as a protection against motor-truck traffic an imposition on the latter of special taxes to an extent sufficient to make carriage by truck unprofitable, and thus force the traffic back to the railroads. The State Ministry of Transportation is favorably inclined toward this plan. The other threat lies in an effort of the alcohol-distilling industry to force the motor industry to use industrial alcohol as an admixture in their regular fuel. It is said that the State Food Ministry is favorably inclined toward this plan.

As regards the railroads, the author of the original article says that with their book value of some thirty billion marks (say, $7,500,000,000) they constitute one of the most valuable properties of the German commonwealth, and that it is in the national interest that their operations should be profitable and successful. The question is, however, whether technical and economic progress elsewhere can be stopped by law. The development of water and highway transportation should not hurt the railroads.

There is no more reason to interfere today with motor-truck traffic in the interests of railroads than there would be at some future date to limit air transportation because of its competition with automobiles. Economic considerations require the existence of motor-truck transportation side by side with railroad transportation, because, under certain conditions, the former may be better and cheaper than the latter.

When a man or corporation has a factory which is likely to become unprofitable he must not expect that the state will step in and stop the operations of his more progressive competitors and thus deprive its citizens of the advantages of better and cheaper industrial performance. The State Railways must learn how to operate so that a box can be transported from Berlin to Potsdam (which happens to be a suburb of Berlin) in less than three days. It must also learn to handle traffic rates not as matter of official power but as an element in a new commercial enterprise. Railroads will have to specialize in a non-bureaucratic way to give better service to their customers (in particular, in the way of freight transportation). They will have to adapt the rail system by the development of rail motor cars, express service, etc., so that it will become a more flexible and individualized method of transportation.

After disposing of the railroad conditions, the author passes to the plans of the German distillery owners, who, acting in the name of national agriculture, though without the support of the State Finance Ministry, want to have a law passed that will make it obligatory to add to all motor fuel from 10 to 25 per cent of alcohol bought at a high price. The state is supposed to provide the capital for additional alcohol plants, while the hundreds of millions of marks of profit is to go into the pockets of some two thousand distillery owners.

The fundamental objection to this plan is that while alcohol mixtures of special types have been tried in the laboratory or under special conditions, their use has not yet been developed to a point where they could be employed on a large scale.

Furthermore, even should the automobile be adapted to the use of such mixtures, only a mixture containing good, harmless alcohol could be used. Such a product can be obtained as long as the driver has the choice of buying it or not. That drivers under certain conditions are perfectly willing to try alcohol mixtures, assuming, of course, that the price is within reason, is shown by the ready sale of monopoline in Germany and lättbenthyl in Sweden, where both products found their way on the market without special compulsory measures being taken.

There is at present in Germany a law which compels the use of $2^1/_2$ per cent of alcohol in motor fuel. But the public prefers to pay a fine rather than use the mixture, with the result that the government is getting in money as a consequence of the existing law but no alcohol is being sold. It is only recently that some movement has been secured through a special arrangement with an existing company which succeeded in disposing of a large amount of alcohol mixture by making it of such a good quality and selling it at such a reasonable price that the public began to buy it voluntarily. (W. A. Ostwald in *Automobiltechnische Zeitschrift*, vol. 33, no. 33, Nov. 30, 1930, pp. 791–792, *g*)

POWER-PLANT ENGINEERING (See also Thermodynamics: The Coefficients of Heat Transfer From Tube to Water)

A Pan-Europe Super-Power System

SUCH a system is under discussion according to the American Committee, World Power Conference, and contemplates linking the water powers of a number of countries with the coal, lignite, and oil resources available. Normally, however, that most of the electricity will be consumed in the country of its origin and the surplus not far from there.

Five trunk lines are contemplated—three running north and south and two east and west, the latter interconnecting the three others. About six thousand miles of high-tension line will be required, and the transmission pressure is to be 380,000–400,000 volts, or double that now in commercial use in this country. Naturally the network will embrace all the industrial districts and large towns of continental Europe, inasmuch as they offer the largest markets for electric power.

The first of the north-and-south lines will connect the water powers of Norway and Sweden with the Central Germany lignite districts by way of Hamburg and Berlin. Thence it will traverse the water-power district of the high Alps, continuing through Brenner Pass to Genoa, and possibly Rome, in Italy.

The second line will start from the vicinity of Calais, France, where large steam power stations will have the advantages of cheap coal from England, Northern France, and Belgium, and will run via Paris and Lyons to the water powers in the Rhone district, continuing to Barcelona and to Zaragoza in Spain where water power is available and finally to Lisbon, in Portugal, which is favorably located for European coal.

The third line will connect Warsaw, Poland, with the German-Polish coal district, and will pass through Czechoslovakia by way of Vienna and the Austrian water-power district to Jugoslavia, thus tapping the water powers along the Dalmatian coast and connecting them with the European super-power system.

Of the lines running in an easterly and westerly direction, the first will tap the north-south line extending from Warsaw near the German-Polish coal regions, where a connection with the Galician oil area is possible. Continuing thence, the line will traverse the lower Silesian coal fields to the Central Germany lignite regions near Halle. There it will cross the north-south line from Norway to Italy and will continue through Western Germany via Coblentz, tapping the west Germany hard-coal and lignite district. Passing thence via Treves to Paris, the line will interconnect with the Calais-Lisbon line.

The second and longer east-west line will extend across the southern section of Europe, taking in Southern Russia and Roumania, to Austria. A part of the general system is already in use. (Abstracted from a mimeographed publication issued by the *American Committee, World Power Conference*, 1419 Chrysler Bldg., New York, N. Y., 4 pp., with map, *g*)

The Benson Boiler at Langerbrugge

THE boiler is designed to heat water at a pressure of 3307 lb. per sq. in. at a temperature of 707 deg. fahr. and then superheat it. The boiler, Fig. 2, is erected out in the open and is of rectangular shape, taking a floor space of 49 ft. 2 in. × 39 ft. 7 in with a height of 106 ft. 5 in. The top of the chimney reaches 147 ft. 7 in.

The combustion chamber is rectangular in form and is surrounded by tube walls. Eight burners coming through the furnace roof blow fuel in from above, which fuel is normally pulverized coal or semi-coke similarly treated. Two supplementary burners are arranged for heavy fuel oil and two for gas, which latter comes from the low-temperature carbonization plant alongside belonging to a company allied to the owners of the Langerbrugge power station, namely, the Centrales Electriques des Flandres et du Brabant.

When starting up, these supplementary burners produce the temperature necessary for ignition. On two opposite sides of the rectangular combustion chamber, external chambers are placed in which are the nests of tubes which operate as reheaters and superheaters.

The water passes through a battery of heating tubes placed in the lower part of the furnace wings operating in four parallel groups composed of 24 serpentine coils. The diagram will help to explain this. The water first passes along the lower section and then to an upper section; the heating tubes are 20 mm. (about 0.8 in.) internal diameter and 33 mm. external diameter, the tube walls being therefore 6.5 mm. or about 1/4 in. thick. The lower section of the heater is placed below the superheater, the upper one above it. On emerging from the upper half of the heater the water enters a low point of the upper half of the radiant-heat-absorbing furnace tube walls. There are 28 parallel tube circuits, the tubes forming a sort of rectangular spiral; they are placed in such a way as to obtain as much as possible uniform heating from the combustion taking place. The steam is collected in a header and then passes downward through the lower-tube-wall radiant section, also in 28 parallel circuits; it then passes through a regulating valve which controls the amount of steam passed, so that it flows into the main outgoing header at a pressure of 200 atmos. (2844 lb. per sq. in.) and a temperature of 450 deg. cent. (842 deg. fahr.).

The high-pressure turbine draws its steam from this heater. The exhaust from the h.p. body then flows back to the boiler at a temperature of 325 deg. cent. (617 deg. fahr.). The steam then passes through 24 groups of tubes each having four parallel circuits, and circulates downward toward a second lower-pressure header which supplies a 25,000-kw. turbine at 823 lb. per sq. in. and a temperature of 842 deg. fahr.

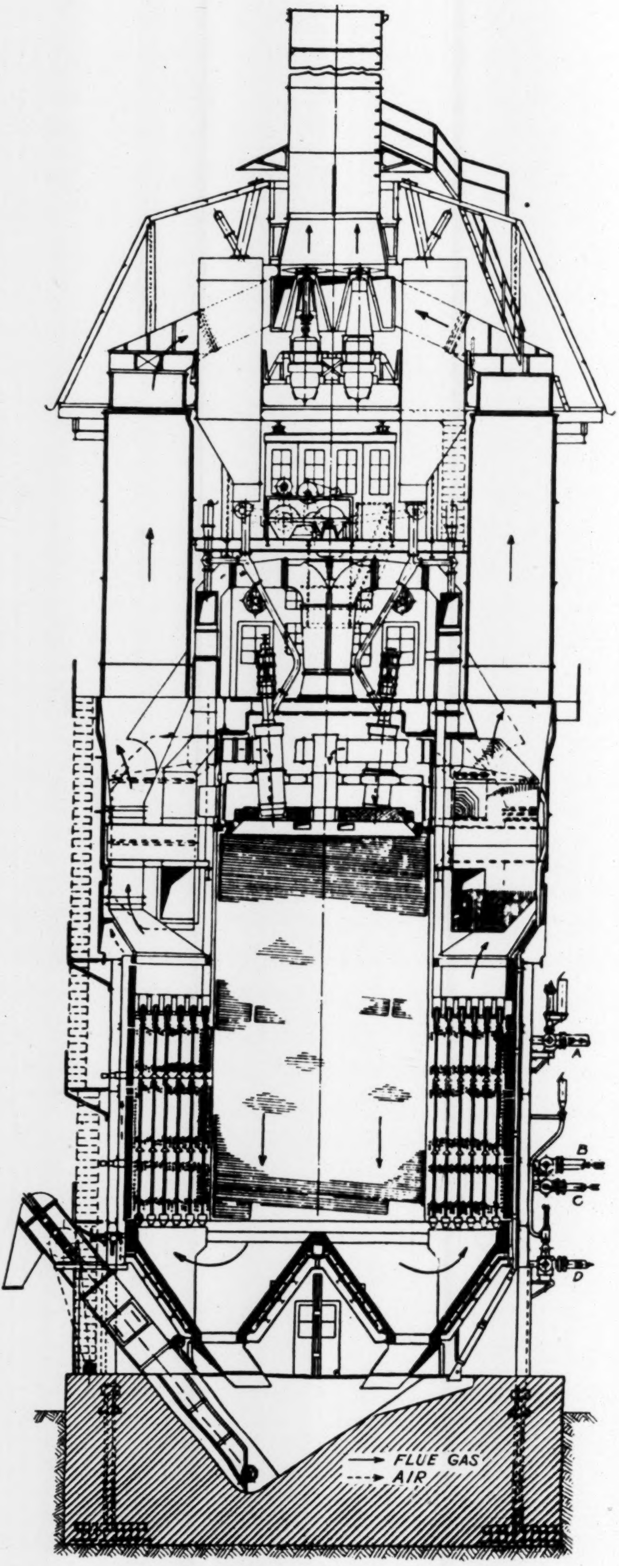


Fig. 2 Sectional Elevation of the Benson Boiler
(A, Outlet from intermediate superheater; B, Inlet to intermediate superheater; C, Inlet to preheater; D, Outlet from boiler.)

There are four air preheaters heating the air to 750 deg. fahr. The diagrammatic layout of the steam system is given in the original article. The operation is as follows: The feed pump forces distilled water heated by steam bleeding to 356 deg. fahr. against a pressure of 3550 lb. per sq. in., which gives an end pressure of 3300 lb. or a little over, the difference being accounted for by the water friction in the small tubes.

The temperature is first raised in steps to 374 deg. cent. (705 deg. fahr.) in the first section of the boiler; it then turns instantaneously into steam and is slightly superheated in the second part of the boiler; the steam is then expanded to 60 kg. per sq. in. (852 lb. per sq. in.) in a 4000-kw. turbine, and after it is reheated through the lateral-tube heater it passes at 710 lb. per sq. in. into a 25,000-kw. turbine.

The boiler has an output of 100 tons of steam per hour under normal duty, 125 tons under continuous overload, and 135 tons for half an hour; superheat, 450 deg. cent. (842 deg. fahr.). The thermal efficiency specified is 87 per cent.

The steam pipework connecting the boiler to the turbine was designed to stand a pressure of 4410 lb. per sq. in. at 842 deg. fahr. The pipes are of special-strength steel of about 50 to 70 kg. per sq. mm. (31 to 44 tons per sq. in.) the outer diameter being 190 mm. (7.52 in.) outside and the walls 0.88 in. thick. The joints are made by rings of steel having a lozenge section, these joints being fixed on the thickness of the tubes by means of screwed flanges drawn together by eight bolts. (*The Electrical Times*, vol. 78, no. 2039, Nov. 20, 1930, pp. 881–882; see also the same publication, October 23, 1930, *d*)

The Power Plant of the Champion Coated Paper Company

THIS plant is located in Hamilton, Ohio, and is said to be the the largest factory in the world run by one boiler and one turbine. It is also said that the boiler is the largest unit-fired pulverized-coal boiler as well as the largest high-pressure boiler yet built.

Briefly, the new plant, built at a cost of about $55 per kw. of capacity, consists of a 600-lb., 750-deg. fahr., 20,000-kw. triple-element turbine and a 650-lb., 750-deg. fahr. pulverized-coal-fired boiler with a maximum steaming capacity of 343,000 lb. per hr. The boiler is of the 3-pass Babcock & Wilcox longitudinal-drum type with a heating surface of 27,192 sq. ft., a 5300-sq. ft. interdeck superheater, a 47,742-sq. ft. tubular air heater, 2620 sq. ft. of Bailey water-cooled walls, and a furnace volume of 19,080 cu. ft. The unit is fired by four 10,000-lb. per hr. Riley duplex pulverizers with an overall boiler efficiency of 86 to 87 per cent. This is the largest high-pressure boiler unit in industrial service, and actually the largest unit-fired installation in the world. The pulverized-coal burners are the largest ever built, one burner having successfully burned 12,000 lb. of coal per hr.

The turbine is a triple-element machine consisting of new General Electric high- and intermediate-pressure elements tacked on to a previously existing Westinghouse low-pressure element. The high-pressure turbine takes steam at 600 lb. gage pressure and exhausts at 175 lb. gage to the intermediate-pressure element and to the 175-lb. gage process line. The intermediate element bled at 90 lb. gage for feed heating exhausts at 15 lb. gage to the low-pressure element and to the 15-lb. process main, while the low-pressure element operates condensing. In the summer the low-pressure element never carries more than 5 per cent of the total element power. In the winter when the heating load is on, the low-pressure element is not needed for balance, so that the average condensing power for the year is about 2 to 3 per cent of the total as compared to about 75 per cent previously. The first two elements drive 9775-kva. 2300-volt generators, and the third a 1875-kva. 440-volt generator.

One of the steps in the betterment program has been to improve engine performance by proper valve setting. The practice has been to throttle the steam and set the valve so that cut-off came near the end of the stroke; in other words, the engines were taking steam practically the entire stroke.

In the installation of the plant several interesting problems had to be solved, for example, that of handling coal and ash. The boiler is of the Babcock & Wilcox cross-drum type with a 54-in. diameter, inside-calked drum 38 ft. 1 in. long.

A 5300-sq. ft. convection superheater is between the fifth and sixth rows, and a 47,742-sq. ft. tubular air heater with a downward gas flow behind the boiler, immediately above the induced-draft fan. The furnace with a volume of 19,080 cu. ft. has a total of 2620 sq. ft. of Bailey water-cooled walls in three sides and bottom. Considering the boiler surface as 100 per cent, the relative values of other parts in per cent are: water walls, 10; superheater, 20; air heater, 175. The furnace volume is 0.54 cu. ft. per sq. ft. of heating surfaces, i.e., boiler proper plus superheater and water walls, and has a heat liberation of about 23,000 B.t.u. per cu. ft. at 400 per cent of rating.

In laying down the feeders, pulverizers, and boiler-control panel two general conclusions were borne in mind: First, that the most serious difficulties are caused by wet or lumpy coal interrupting the feeding at partial gate openings; and second, that as the totally enclosed pulverizer in itself gives the operator no indication of its performance, the operator can only shut it off if anything goes wrong.

To avoid this the feeders have been provided with variable-feed tables and the pulverizers located on the level below the firing floor where they are out of the fireman's way. The upper spouts have been cut short so that the coal flow to the feeder is visible to the fireman at all times.

Control of the feeders, pulverizers, and draft fans is from a central boiler panel on the firing floor.

Its center section consists of a mimic diagram showing the flow of coal from the bunker through to the furnace; the flow of coal, air, and gases into and out of the boiler; the flow of feedwater into the boiler and the flow of steam out. Various wattmeters indicate the performance of the various machines. For instance, the four top wattmeters indicate the speed of the four feeders. From the feeders, the flow of coal is down through the mills, with the performance indicated by the second row of meters, and into the boiler. Operation of the forced- and induced-draft fans is shown by the two wattmeters at the side of the boiler. Alarms at the bottom of the panel indicate high and low water levels.

Each feeder can be controlled individually or by the master controller shown between the two center grips. Pulverizers can be started or stopped by the push buttons immediately beneath the respective ammeters, as can the forced- and induced-draft fans. A push button in a glass case below the boiler shuts down the entire plant and closes the boiler stop valve in case of an emergency. This can also be done from similar buttons placed elsewhere in the plant, one in the turbine room and another just inside of the boiler-room door. Other instruments are located on the panel. The forced- and induced-draft fans are located on the main floor immediately back of the boiler, with the controllers immediately above on the firing floor. This not only simplifies the structural design but gives the fans a solid foundation in an accessible location. In case of trouble with the remote control the manual control directly above on the firing floor can be reached by the fireman without leaving his floor.

Stack sprays are provided for the elimination of fly ash, and the stack has been lined with vitrified tile and acid-proof cement. Data as to screen tests of solids in the gas and gas velocity up the stack are given in the original article. The gas flow entering the stack is downward, which is followed by a sharp bend upward so that moisture or ash particles which might otherwise be carried along in the gas stream are precipitated out as in a steam separator. (*Power Plant Engineering*, vol. 34, no. 23, Dec. 1, 1930, pp. 1328–1340, 22 fig., *dA*)

RAILROAD ENGINEERING

A Central Energy System for Trains

THE Baltimore and Ohio Railroad Company has developed a system of continuous electric-power supply for trains modeled after central-station supply and distribution systems. The system is designed to supplement present lighting systems and to provide a source of electrical energy for the operation of air-conditioning equipment, electric refrigeration, coffee percolators, etc.

In this system an alternating-current steam turbo-generator is mounted at the front end of the locomotive and the steam is supplied from the locomotive, the engineer only opening and closing the steam supply valve.

Sixty-cycle single-phase alternating current at 220 volts is conveyed from the generator to the several cars on the train. Each car is equipped with an air-cooled transformer of 1.5 kw. capacity which reduces the lighting voltage to the standard of 32 volts. The electric connections between the tender and the several cars in the train are made automatically through the Tomlinson tight-lock type of automatic coupler, which automatically connects the steam, air-brake signal, and electric train lines. The alternating current of sixty cycles was selected because it is generally available at passenger stations and can be supplied when cars are parked at stations or in the yards. Details of the Tomlinson couplers are given in the original article. (*Railway Age*, vol. 89. no. 22, Nov. 29, 1930, pp. 1170–1172 and 1182, illustrated, *d*)

Operating Results With the Timken Locomotive

THIS locomotive was built for demonstration purposes. The wheel diameter was selected as a compromise between prevailing practice in passenger and freight service and is 73 in. The boiler is of sufficiently large capacity to handle heavy trains at high speeds. This influenced the decision in favor of the 4-8-4 arrangement of wheels.

The weight was held within the limitations imposed by those roads having a maximum of 61,000 lb. per axle, and recognition of the fact that this would limit the capacity of the locomotive on roads permitting higher axle loads led to the development of a duplex weight system whereby a weight of 66,000 lb. per axle is used with 250-lb. steam where heavy axle load is permissible, whereas an axle limit of 61,000 lb. with 235-lb. of steam meets the conditions imposed by roads having lighter axle limits.

The roller bearings are applied on the engine trucks, drivers, trailer, tender, booster, train control, valve pilot, and flue blower. The driver bearings are of the single-bearing type and provide one row of rolls adjacent to each wheel. Both bearings are mounted in a one-piece housing extending across the frame. The axle unit thus comprises the axle and wheels, bearings, and housings, thus insuring maintenance of alignment between these parts irrespective of the condition of rolls and oscillation in the locomotive frame. It is claimed that lubrication does not require attention more often than two or four times a year. The main and side rods, motion work, and all spring and brake fittings and pedestal liners are equipped with the Alemite system of lubrication.

The Timken bearings have been in service since April, 1930, and the wastage of oil has proved to be very small.

The locomotive has been operated on several railroads both in passenger and freight service. It is claimed that the runs so far made indicate that the roller bearing provides a means of developing a combination engine which is capable of handling all freight service with the exception of the heavy drag coal service, and which without making any changes whatever will handle any passenger schedule and do both jobs in an efficient manner.

The roller bearing in locomotive construction has improved the reliability of the machine. The Timken engine has been in service since April 15, and has taken every train into the terminal. It has started every train without issuing calls for a helper, notwithstanding some starts were made on momentum grades where the trainmen were of the opinion that the regular plain-bearing locomotives would have required a call for help.

The locomotive has handled 12 steel cars up the Allegheny grade at Gallitzin without a helper, and with this train saved three minutes on the standard mountain schedule.

Details as to behavior of the train in coasting and starting as well as bearing temperatures are given in the original article. There has been a surprising amount of saving in reduced consumption of coal and water, which the author does not ascribe entirely to the presence of the bearings, however. The best judgment indicates that the roller bearing saves between 10 per cent and 20 per cent of the total power development, the wheel bearing friction being practically eliminated. Final tests have not determined the machine efficiency.

The interesting feature is that the saving due to the roller bearing is applicable directly to the rail, and this saving is compounded throughout the various features of the locomotive. If it is assumed that a certain amount of work is to be done which is limited by train size, the power saving in the bearings effects, first, an economy in the cylinders due to early cut-off, which involves corresponding reduction in the consumption of steam. This in turn involves a second reduction in blast at the nozzle and effects more uniform draft conditions in the smokebox. The saving in one and two reduces the demand on the boiler and results in the working of the boiler at a higher point on the boiler-efficiency curve, effecting a still further reduction in power. One, two, and three react together to effect a reduction in demand on the furnace and permit again a reduction in demand on the furnace and permit again the operation of the grate on a proportionately higher point on the efficiency curve.

The saving in power at the wheels is therefore compounded four times, and this feature is believed to account for the economy in fuel and water which could not be accounted for by the saving in bearing friction alone. (T. W. Buckwalter, Vice-President, Timken Roller Bearing Co., in a paper presented at a meeting of the Central Railway Club, New York, Nov. 13, 1930; abstracted through *Railway Age*, vol. 89, no. 22, Nov. 29, pp. 1177–1182, illustrated, *d*)

THERMODYNAMICS

Thermal Conductivity of Liquids

FROM this investigation it would appear that impurities in the liquids probably account for most of the difference between the values given by the author and those of other observers.

The first five liquids were tested at least twice to see if the results were reproducible, and it was found that they were, in general.

If we assume that the 0.2 per cent impurity in the ethyl alcohol tested was water, then, for 100 per cent pure ethyl alcohol the thermal conductivity would be 0.000433, which checks Bridgman and Goldschmitt closely, and also checks the author's value obtained last year.

Since the conductivity of liquids increases with pressure by only about 2 per cent per 100 atmos. at 30 deg. cent. and 75 deg. cent., according to Bridgman, it can be neglected for ordinary calculations involving moderate pressures.

In the discussion of the original paper the author presents a proposed general equation for the thermal conductivity of all non-metallic liquids at 30 deg. cent. and atmospheric pressure. This equation is:

$$k = 8.1 \times 10^{-4} \frac{\rho C^{0.4}}{Z^{0.12}} (CM^{1/6})^{1.15}$$

or

$$k = 8.1 \times 10^{-4} \frac{\rho^{2.15} C^{1.55} M^{0.192}}{Z^{0.12}}$$

where

k = thermal conductivity at 30 deg. cent. in gm. cal./(sec.) (sq. cm.) (deg. cent./cm.)

ρ = specific gravity of liquid relative to water at 30 deg. cent.
Z = viscosity of liquid in centipoises
C = specific heat of liquid, and
M = molecular weight of liquid.

All values are to be obtained at 30 deg. cent.

By plotting $\left(\frac{k \times 10^4 \times Z^{0.12}}{\rho C^{0.4}}\right)$ against $(\rho CM^{1/6})$ we can get a straight line on logarithmic paper having a slope of 1.15. This plot may be used instead of the equation for determination of thermal conductivities.

The agreement of this equation with experimental observation is quite remarkable. Outside the oils (whose properties were not definitely determined) only one liquid had an error of 4.5 per cent. All others checked to closer than 3.5 per cent. Since these liquids include water and some alcohols of high thermal conductivity, the result is very gratifying.

The list of liquids used in this determination is given in the original article, with some data as to their properties. The equation above does not give the temperature coefficient. (J. F. Downie Smith, *Industrial and Engineering Chemistry*, vol. 22, no. 11, Nov., 1930, pp. 1246–1251, illustr., *e*)

The Coefficients of Heat Transfer From Tube to Water

THE present investigation was undertaken with the object of determining as fully as possible the way in which the coefficient of heat transfer varies with the physical properties of the fluids employed. It was in the first instance confined to determining the phenomena on the water side of a condenser tube. The tube was heated electrically by passing through it a low-tension alternating current. By this means the rate of heat flow into the water is under precise control and can be varied exactly as desired. The amount of heat put into the water in a given length of tube is also known, and as the outside of the tube is dried the temperature of this surface can be more easily obtained by thermocouples than when these have to be protected from the steam by another tube, or varnish, or other means.

The author points out the complexity of the problem and describes the apparatus used as well as the method of procedure. The water velocities most generally employed were 2 ft., 3 ft., 5 ft., 8 ft., and 11 ft. per sec.

Whenever heat was switched on, it was noticeable that the water heights in the manometers fell slightly, and in most cases the water weight slightly increased. This was more pronounced at low water temperature, when the stop valve had to be adjusted to reduce the flow and fresh weighings taken till the correct flow was again obtained. It was impracticable, however, always to work with the exact water velocity desired, so it was endeavored to get it correct to within 1 per cent, and to apply a correction to the coefficients of heat transfer obtained, these being taken as varying as the 0.8 power of the velocity.

The effect of dirt on the inner surface of the tube was well shown during the early period of the tests. A number of tests had been carried out with various water velocities and inlet temperatures, and the coefficients of heat transfer calculated for the conditions at the thermocouples. These were plotted against the water temperature of the thermocouples, and as the plotted points were somewhat irregular a number of the tests were repeated, when it was found that consistently lower values were obtained, the difference being greatest when comparison was made with the earliest tests. It was found that after the tube had been in use for about 50 hr. the values of the coefficient of heat transfer at 7 ft. per sec. had dropped as much as 15$^1/_2$ per cent, while the manometer showed that the hydrostatic resistance over the 5-ft. 3-in. length had increased by 9 per cent. Similar results were obtained at a velocity of 4 ft. per sec.

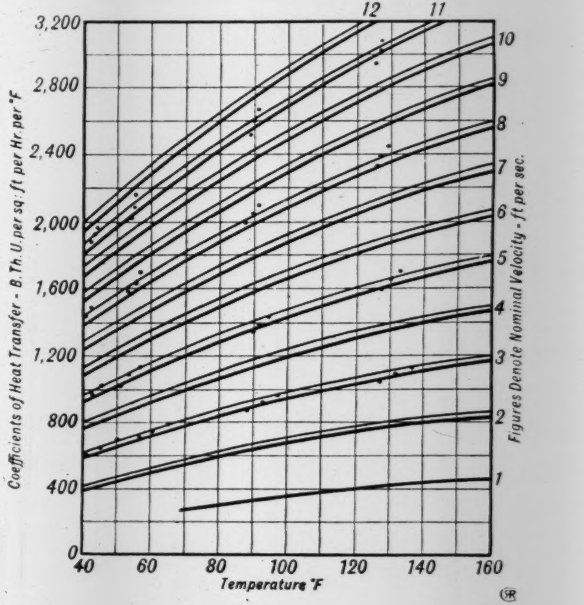


Fig. 3 Coefficients of Heat Transfer From Tube to Water

The tube was inspected by drawing a flashlight bulb through it, and it was seen that the surface was covered with a fine brown deposit, largely an iron hydroxide from various pipes of the supply system. This difficulty was overcome subsequently by drawing a well-rinsed wash-leather plug two or three times through the tube after every two or three hours of use and by cleaning out the supply tank occasionally.

The results of the tests are shown in the original article by curves in a diagram where the points are the coefficients of heat transfer at the outlet thermocouple for three heat-flow rates of approximately 4,000, 12,000, and 20,000 B.t.u. per sq. ft. per hr. plotted against water temperature at the thermocouple for various nominal velocities. The curves are for the heat-flow rates of 0 and 20,000 as deduced from tables given in the original article, which combine the whole of the experimental tests and are applicable to tubes of any diameter (Fig. 3).

Too much stress must not be laid on the discrepancy seen in Fig. 3 between the spacing of the points at high water temperatures and velocities and the spacing indicated between the zero and 20,000-B.t.u. per sq. ft. per hr. curves. With the hot-water points shown at 11 ft. per sec. the three temperature differences from tube to water for the three heat flows were 1.36 deg., 3.97 deg., and 6.50 deg. fahr. These were the results of smoothing the three experimental values graphically against the heat-flow rate. Had the points been smoothed to a curve of slightly less curvature so that they became 1.33 deg., 3.95 deg., and 6.50 deg. fahr., the spacing of the points would have been reduced to half that given here. Thus 50 per cent of the spacing depends on a temperature difference of only 0.03 deg. fahr. As the inlet water was steam heated to about 125 deg. fahr., it was difficult to keep its temperature constant to this degree of accuracy.

As regards the loss of hydrostatic head along the tube during heat transfer, it was found that this loss was, within the margin of experimental error, sensibly the same as if there had been no heat transfer present and the water had been throughout at the actual temperature of the tube wall.

Thus one can say that the loss of head depends upon the tube-wall temperature and is independent of any heat transfer taking place. This law was seen to be slightly departed from in the case of very cold water at temperatures down to 40 deg. fahr. The remainder of the paper includes a discussion of the theory of heat transfer, in the course of which Osborne Reynolds' theory on the subject propounded in 1874 was subjected to criticism. The authors advanced a modified theory which led to the formula

$$10{,}000\ V_n K_0 = A + B\,(\sigma - 1) - C(\sigma - 1)^2$$

where K_0 is the coefficient of heat transfer at zero rate of heat flow, V_n the nominal velocity, and σ is $\mu s/c$, where μ is the viscosity of the fluid, s its specific heat, and c its thermal conductivity. In a table the values of the "constants" A, B, and C were given, and in another table the value of the quantity σ was shown for water at temperatures from 32 deg. fahr. ($\sigma = 12.45$) to 320 deg. fahr. ($\sigma = 1.02$). The paper concluded with the discussion of an approximate formula whereby the value of the coefficient of heat transfer K_H, when the rate of heat flow has any finite value can be determined from the corresponding value K_0 given by the above formula for the condition of zero heat flow. (Albert Eagle and R. M. Ferguson, Institution of Mechanical Engineers Report Ref.H/T 16, received from the British Electrical and Allied Industries Research Association; abstracted through *The Engineer*, vol. 150, no. 3907, Nov. 28, 1930, pp. 605–607, 3 figs., *e*)

WELDING

Non-Destructive Tests of Welds

IN THE case of welds, non-destructive testing is particularly important because the quality of a weld is affected by a number of factors which may not have been active in the case of any other weld. Destructive testing may therefore be used for purposes of general investigation, but indicates little as to the quality of any other weld but the one tested to destruction. Of late magnetic methods of testing have been developed, however, which may be applied to the investigation of individual joints without destroying them. These methods are applicable to butt welds, i.e., welds in which the edges are jointed together without lapping. The apparatus is portable and is said to require very little skill and training on the part of the tester.

The tests are made by "bridging" the welded seam with a large horseshoe electromagnet and "exploring" the magnetic field in the vicinity of the weld with a meter.

This is really a further development of the method devised by M. Roux, a French investigator, to "explore" the weld by placing iron filings on a piece of paper over the weld and observing the density of the filings as they are affected by the density of metal in the weld. This method, however, is good only when the surface is smooth and the faults are not too far below the surface.

By passing the meter over the weld and watching the pointer, the quality of the weld can readily be determined. The meter indicates the "reluctance" of the weld by "reading" the magnetizing forces across the weld as compared with the magnetizing forces of the steel plate. If the magnetizing forces are about the same, the weld is good; if not, the weld is bad and the meter will tell just how bad it is.

This method is practically indifferent to the depth of the fault below the surface and is only slightly affected by a rough, uneven surface. Various new types of weld test-meters are now being developed.

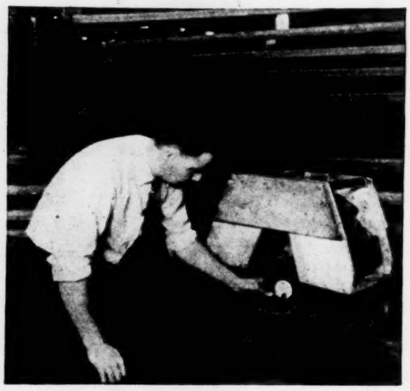


FIG. 4 NON-DESTRUCTIVE METHOD OF TESTING OF WELDS BY BRIDGING

After several months' investigation of both the "iron-filing" and weld test-meter methods by the research laboratories, they are expected to be used in the near future at the East Pittsburgh Works of the Westinghouse Electric & Manufacturing Co. on large butt welds in structures such as generator-frame rings, flywheel rims, and welded pipe. (T. P. Watts, of the Research Laboratories, Westinghouse Electric & Mfg. Co., before the American Welding Society, September 24, 1930, Chicago, Ill., *d*)

Resistance Welding of Steel Joists

IT DOES not appear that we can place any exact limits upon the pressures and current densities desirable for this purpose at this time because of the wide variation in practice in various shops, all of which are producing good welds. We may, however, say in a general way that there should be from 200 to 300 kw. of energy available for each square inch of surface to be welded, and that the pressure should be between 8000 and 10,000 lb. per sq. in. of weld. With these two conditions established, the remaining factor, time, may be varied to obtain satisfactory welds. The time will usually be found to be between $^1/_6$ sec. and $1^1/_2$ sec.

It has been found that a slight coating of rust on the steel to be welded is of advantage, but a heavy coating will prevent the flow of current and formation of a weld.

Just before the current is applied the pieces to be welded are forced together with a pressure of about 2000 lb. per sq. in., and this is quickly raised to from 8000 to 10,000 lb. per sq. in. after the current is applied. The result is a perfect fusion of metal at the junction which is free from slag or oxide (also from nitrides) without any appreciable distortion of the metal more than about $^1/_{16}$ in. from the junction. Within the space of about $^1/_{16}$ in. or less from the junction the metal will have flowed quite freely, forming a perfect joint with a little excess of metal extruded around the edges.

A single-phase alternating current is used and is transformed from the line voltage to from 5 to 14 volts on open circuit. When the circuit is closed, about one-half of the total energy is dissipated in iron and copper losses in the transformer. The resulting secondary current is from 20,000 to 40,000 amperes per sq. in. of welding area. The heat rise is very rapid, but by no means uniform.

The shape of the pieces to be welded is of great importance. In welding thin sheets there is a danger that the pressure of the electrode will produce a condition resulting in a reduction of the strength of the sheet around the weld and a ultimate tear of the sheet. The plain butt weld is the ideal resistance weld, and the author describes a number of forms of welds and their physical properties. From these it would appear that the strength of the weld is substantially the same as that of the original metal, but that the properties of the metal are somewhat affected by the heat of the weld.

The making and breaking at frequent intervals of such large-current circuits as are required in this work places a very heavy burden upon the generating station. If a station of large capacity is available the inequalities in current demand can be absorbed, but if a small generator is to be used it must be provided with an ample flywheel. Even with current from a large power station it is necessary to provide ample capacity across the lines to absorb the line surge. (Frank Burton, Cons. Engr., Detroit, in *Journal of the American Welding Society,* vol. 9, no. 9, Sept., 1930, pp. 78–87, *pd*)

The Welding of Corrosion-Resisting Steels

THE author discusses the welding of chrome irons with a carbon content of less than 0.20 per cent; chrome steels with carbon more than 0.20 per cent; chrome-nickel irons with carbon less than 0.20 per cent, and chrome-nickel steels with carbon more than 0.20 per cent. The division is arbitrary, but corresponds to a marked difference of the physical properties and weldability of the alloys falling within these classifications.

The general conclusions to which the author comes is that, in so far as chrome irons are concerned, the weldability depends on the chromium content. Taking 14 per cent as the dividing point, it is found that welds made in alloys above this amount are subject to considerable grain growth as the result of high welding heat, and it is not possible to correct this condition by common heat treatment.

Welds in this type of alloy are therefore not recommended. On the other hand, because of air-hardening properties, welds made on irons with the chromium content less than 14 per cent should be annealed after completion of the welding operation, which will give the maximum ductility and toughness that can be obtained with these alloys. The author discusses the matter of annealing in detail.

As regards chrome steels with carbon over 0.20 per cent, these are non-air-hardening. The welding does not offer any particular difficulty and the welds in general need not be annealed, although this depends on the particular metal and service to which it will be put. Steels with a carbon content of over 0.20 per cent and chromium content of 12 to 14 per cent depend in general for their stainless properties on the surface finish and heat treatment. While annealing and slow cooling overcome to a certain extent the brittleness and hardness of the welds and metal adjacent thereto, this treatment would in a manner destroy the corrosion-resisting properties of the alloy which were developed by quenching, drawing, and surface-finishing operations. Welding is therefore not recommended for this class of steels.

When dealing with chrome-nickel irons with carbon less than 0.20 per cent (usually referred to as 18–8) there are certain physical properties of this class of alloys which must be taken into account in welding operations. Some of these alloys possess only one-third of the heat conductivity of ordinary steels, while at the same time they have an expansion coefficient about 50 per cent greater than that of steel. It is these properties that cause the greatest difficulty in welding alloy steels belonging to this group. The matter of expansion must be carefully controlled. The use of suitable clamps and jigs is often necessary for successful welding. Backing-up strips of heavy copper slabs with or without the aid of water cooling assist materially in keeping the temperature down and therefore lessening the expansion of the material. The use of lower heat values in welding, as compared with steel, is also a necessity. As indicated later on in the general technique for welding, rapidity of the welding operation is very desirable.

In general, it may be stated that welds and adjacent material in this class of alloys are ductile and require no subsequent heat treatment. The addition of about one per cent each of manganese and silicon apparently improves the welding quality. However, for very severe service, subjected to corrosive fatigue action, heat treatment will remove any strains and therefore raise the endurance limit under these conditions. Annealing also serves to increase the ductility and tensile strength.

Welds made with this class of steel would have a tensile strength ranging from 65,000 to 75,000 lb. per sq. in., with a corresponding yield point of from 50,000 to 60,000 lb. per sq. in., with an elongation of about 15 per cent in 2 in. Welds of even greater tensile strength and ductility have been produced.

The annealing temperature would be dependent somewhat on the material, but would be of the order of 1750 deg. fahr. to 2100 deg. fahr. In contrast to ordinary iron and steel this temperature should be attained quickly and the material also cooled rapidly. Quenching in water is recommended for small articles.

As indicated previously, this group lends itself most readily to welding, and the author recommends the use of steels falling within this classification wherever possible.

The only difference in so far as chrome-nickel steels with carbon contents of more than 0.20 per cent are concerned, is that annealing is generally recommended, and where the corrosion- and heat-resisting properties are dependent on cold-working or surface-finish, welding is not recommended. (First of a series of articles by Wm. F. Spraragen, Secretary, Division of Engineering, National Research Council, 29 West 39th Street, New York, in *Welding,* vol. 1, no. 13, Nov., 1930, pp. 897–900, illustrated, *pA*)

VARIA

Blast-Furnace Efficiency

WHILE the blast-furnace production of pig iron and ferro-alloys increased 16.8 per cent in 1929 over 1927, according to the 1930 census of manufactures, the number of producing establishments declined 11 per cent and the number of wage earners dropped off 6 per cent.

Yet at the same time blast-furnace products showed an appreciation in value of an approximate $60,000,000, practically double in comparison with the increase from 1927 to 1929 of the cost of materials, fuel, and electric current in making these products. (*Steel,* vol. 87, no. 26, Dec. 25, 1930, pp. 24, *g*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Instruments and Apparatus

Preliminary Draft of Part 16—Density Determinations

The Main Committee on Power Test Codes takes pleasure in presenting to the members of the Society for criticism and comment Part 16, "Density Determinations," of "Instruments and Apparatus." The Individual Committee which has developed this draft consists of Messrs. C. F. Hirshfeld, Chairman, W. A. Carter, Secretary, C. M. Allen, E. G. Bailey, L. J. Briggs, C. R. Cary, J. D. Davis, R. E. Dillon, F. M. Farmer, J. B. Grumbein, W. H. Kenerson, E. S. Lee, E. L. Lindseth, O. Monnett, S. A. Moss, R. J. S. Pigott, and E. B. Ricketts.

The "Instruments and Apparatus" Section will consist of twenty-one parts dealing with the following subjects: (1) General Considerations,[1] (2) Pressure Measurement (6 chapters),[2] (3) Temperature Measurement (9 chapters), (4) Head Measurement, (5) Measurement of Quantity of Material, (6) Electrical Measurements, (7) Mechanical Power, (8) Measurement of Indicated Horsepower, (9) Heat of Combustion, (10) Flue-Gas Analysis, (11) Determination of Quality of Steam, (12) Time Measurements, (13) Speed Measurement, (14) Mechanical Measurements, (15) Surface Area, (16) Density Determinations, (17) Determination of Viscosity of Liquids, (18) Humidity, (19) Concentration of Dilute Solutions, (20) Smoke-Density Determinations, and (21) Leakage Measurements (2 chapters).[3]

The Individual Committee, the Main Committee, and the Society will welcome suggestions for corrections or additions to this draft from those who are especially interested in this subject. These comments should be addressed to the Chairman of the Committee, in care of The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.

Table of Contents

Paragraph
General 1
Standards 5
Methods 7
  Solids
    Measuring and Weighing 8
    Picnometer 9
    Hydrostatic Weighing 12
  Liquids
    Picnometer 14
    Hydrostatic Weighing 16
    Hydrometer 18
    Westphal Balance 23
  Gas or Vapor 24
Range and Accuracy 25

General

1 Density is defined as the mass per unit volume. The units most commonly used to express density are grams per cubic centimeter (or milliliter)[4] and pounds per cubic foot. The temperature at which a density determination is made should always be stated.

2 Specific gravity is an abstract number expressing the ratio of the weight of a given volume of a substance to the weight of an equal volume of a standard substance under standard conditions. Water is often used as the standard substance. In the case of specific-gravity determinations both the temperature of observation and the temperature of reference must be given.

3 Density and specific gravity while fundamentally different are nevertheless determined in the same way and may have the same numerical values. Care must be taken, however, to state the units employed and the temperature involved, otherwise there is danger of confusion and misinterpretation of results.

4 Specific gravity may be determined at any convenient temperature and referred to water at any desired temperature. For example:

$$\text{Specific gravity}\ \frac{X^\circ}{Y^\circ}$$

where X is the temperature of the material and Y is the temperature of the water (test liquid). In order that specific-gravity values may be directly comparable, they must be reduced to the same temperature and expressed in terms of water at the same temperature.

Standards

5 In order that values of specific gravity in the Power Test Codes may be uniform and directly comparable, water at 39.2 deg. fahr. is designated as the standard of reference in all cases where practicable.

6 The specific gravity of gases shall be expressed at a pressure of 30 in. Hg and at a temperature of 68 deg. fahr. Air at a pressure of 30 in. Hg and at a temperature of 68 deg. fahr. is the standard of reference and is considered as unity.

Methods

7 Specific-gravity determinations[5] may be divided into three classes according as the materials are solid, liquid, or gaseous. The available methods for each class of substances are as follows:

- I Solid
  - (*a*) Measuring and weighing
  - (*b*) Picnometer
  - (*c*) Hydrostatic weighing
- II Liquid
  - (*a*) Picnometer
  - (*b*) Hydrostatic weighing
  - (*c*) Hydrometer
  - (*d*) Westphal balance

---

[1] See pamphlet published, June, 1928.

[2] Chapter 1 of Part 2 on "Barometers," was published in pamphlet form, June, 1929.

Chapter 6 of Part 2, on "Tables, Multipliers, and Standards for Barometers, Mercury and Water Columns, and Pressure Measurements," was published in pamphlet form in June, 1929.

[3] Chapter 1 of Part 21, on "Condenser Leakage Tests," was published in pamphlet form in November, 1928.

[4] The cubic centimeter (the volume of a cube 1 cm. on a side) is not exactly equal to the milliliter, but the difference is so slight as to be negligible in all ordinary density determinations. The milliliter is equal to 1.000027 cubic centimeters. (See Travaux et Mémoires du Bureau International des Poids et Mesures, XIV, 1910.) In all volumetric measurements the milliliter is the unit of volume employed, though it is referred to as the "cc." or the "ml." When the cubic centimeter is actually employed it should be written "cm.³" and not as "cc." The cubic centimeter is usually employed to express volumes calculated from linear measurements.

[5] For special methods for the determination of specific gravity, such as for coal, coke, lubricating oil, etc., the test engineer is referred to the A.S.T.M. Standards applicable.

III Gas or Vapor
- (a) Effusion
- (b) Specific-gravity balance (Edwards).

In the following discussion it is assumed that apparent specific gravity[6] is desired; that is, the apparent weights[7] have not been corrected for the buoyancy of the air. If true density or true specific gravity is desired, all weighings must be reduced to vacuo.

SOLIDS

8 *Measuring and Weighing.* The density of solids may be determined by weighing the sample in air and using the equation

$$d = \frac{m}{v}$$

in which d = density
m = mass (weight of sample), and
v = volume of sample.

The volume in this method is obtained by linear measurement (caliper or length scale) of the dimensions of the sample and computation therefrom. This method is limited to solids that have regular geometrical forms, the volumes of which can be determined from linear dimensions. The approximate volume of irregular solids may be determined by liquid displacement in a graduated vessel.

9 *Picnometer.* The picnometer is essentially a glass vessel of definite volume. Those shown in Fig. 1[8] can be used for determining the density of either solids (in small particles or crystals) or liquids. Picnometers (a) and (d) (Fig. 1) are the types ordinarily employed; care must be taken, however, to set the stopper uniformly so as to avoid the possibility of error due to variations in the volume of the picnometer. The other picnometers, (b) and (c), are of somewhat special design and have been found to be very satisfactory in the laboratory of the Bureau of Standards. Picnometer (e) is used by the A.S.T.M. in the determination of "Specific Gravity of Road Oils, Road Tars, Asphalt Cements, and Soft Tar Pitches." Serial designation: D 70-27.

10 Special picnometers suitable for viscous or volatile liquids, whenever extreme accuracy is desired, are described in Bureau of Standards Technologic Paper No. 77, "Density and Thermal Expansion of American Petroleum Oils," by H. W. Bearce and E. L. Peffer, and Bureau of Standards Scientific Paper No. 197, "Density and Thermal Expansion of Ethyl Alcohol and Its Mixtures With Water," by N. S. Osborne, E. C. McKelvy, and H. W. Bearce.

11 For specific-gravity determinations of solids by the use of a picnometer, four weighings are made as follows:

- (a) Picnometer empty and dry (P)
- (b) Picnometer and specimen ($P + S$)
- (c) Picnometer, specimen, and water or other test liquid to fill picnometer ($P + S + w$)
- (d) Picnometer filled with water or other test liquid ($P + W$).

The specific gravity of the sample at the temperature of observation is found according to the equation,

$$\text{Specific gravity of sample} = \frac{S \times d}{W - w}$$

in which
S = weight of specimen
w = weight of test liquid put in with specimen
W = weight of test liquid to fill empty picnometer
d = density or specific gravity of test liquid.

12 *Hydrostatic Weighing.* In the method of hydrostatic weighing, the sample is first weighed in air and then suspended in the test liquid and its weight therein determined. This is done by using a silk thread or very fine wire attached to a small basket in which the sample is placed in the liquid suspended from one arm of an equal-arm balance. It is necessary to have the thread or wire passing through the surface of the liquid with the basket attached in making the balance reading before the sample is placed thereon, in order that errors due to the additional weight of this attachment and to the effect of surface tension of the liquid on the suspension fiber may be avoided. A fine wire is preferable to the silk thread since large errors may be introduced on small samples by the use of the thread.

13 The density of the sample is the weight in air divided by its volume. This volume, in metric units, is equal to the loss of weight of the sample, divided by the density of the test liquid at the temperature of observation.

LIQUIDS

14 *Picnometer.* In carrying out specific-gravity determinations of liquids by means of a picnometer, it is convenient to calibrate the picnometer and to tabulate the volume at various temperatures.

15 The specific gravity of a liquid at any temperature in the range covered by the picnometer calibration can then be calculated at once by dividing the weight of the liquid contained at any temperature by the weight of water at the same temperature. In order that specific-gravity determinations may be comparable and to avoid the necessity of reducing observed specific gravities to the desired basis, a temperature-control bath is convenient.

16 *Hydrostatic Weighing.* The hydrostatic-weighing method and the picnometer method are susceptible of a higher degree of accuracy than is obtainable by the use of either the hydrometer or of the Westphal balance. Some means of temperature control should be provided to obtain the best results. The condition of the suspension wire where it passes through the surface of the liquid is important and for accurate weighing the diameter should be as small as is consistent with safety, and the surface of the wire should be either coated with platinum black or plated with unburnished gold. This roughening of the suspension wire is very important as it eliminates much of the variation in surface-tension effect on the suspension.

17 In this method a sensitive chemical balance and precision weights are necessary. The sinker or plummet[9] should have a volume of 50 to 100 ml. (cc). Knowing the mass and volume of the sinker and observing the loss of weight of the sinker on immersion in the liquid, the density is computed according to the formula

$$d = \frac{m}{v}$$

---

[6] In scientific circles, specific-gravity and density determinations made in air (that is, uncorrected to vacuum) are frequently distinguished by the adjective "apparent." ("Standard Definitions of Terms Relating to Specific Gravity," A.S.T.M. Serial Designation: E 12-27.)

[7] The buoyancy correction to be added to any apparent weight, to reduce it to true weight in vacuo, is calculated by multiplying the air density by the difference in volume between the object weighed and the weights required to balance it on an even-arm balance; or

$$B = \rho(v - v_w)$$

in which B = air buoyancy, ρ = air density, v = volume of object weighed, and v_w = volume of weights.

[8] Not reproduced here.

[9] The calibration of a plummet is described in Supplement No. 1 to Miscellaneous Publication No. 15 of the Bureau of Standards.

in which d = density, m = mass of displaced liquid, and v = volume of displaced liquid-volume of sinker.

18 *Hydrometer.* In the determination of the specific gravity of liquids, where convenience is one of the prime considerations, the hydrometer is very satisfactory. The use of this instrument, however, is limited to liquids that are relatively transparent and fluid. The careful operator can, by using a hydrometer that has been accurately calibrated, obtain results that are correct to within one of the smallest subdivisions of the scale. In the case of instruments classed as "precision" this is usually one in the third decimal place in specific gravity and one-tenth of a per cent if the instrument is graduated in percentages. In order to avoid large corrections, due to changes in the volume of the hydrometer and in the density of the liquid, hydrometer readings must be made at or near the standard temperature of the instrument.

19 The correct method of reading the hydrometer is illustrated in Fig. 2.[8] The sample of liquid is placed in a clear glass jar or cylinder and the hydrometer carefully immersed in it to a point slightly below that to which it naturally sinks (not over $^1/_8$ in.), and is then allowed to float freely.

20 The reading should not be taken until the liquid and the hydrometer are free from air bubbles and are at rest.

21 In taking the reading in transparent liquids, the eye should be placed slightly below the plane of the surface of the liquid, and then raised slowly until this surface, seen as an ellipse, becomes a straight line.

22 In case the liquid is not sufficiently clear to allow the reading to be made as above described, it will be necessary to read from above the surface, and to estimate as accurately as possible the point to which the liquid rises on the hydrometer stem. It should be remembered, however, that the instrument is calibrated to give correct indications when read at the principal surface of the liquid. It will be necessary, therefore, to correct the reading at this upper meniscus by an amount equal to the height of this point on the stem of the hydrometer, above the principal surface of the liquid. The amount of this correction may be determined with sufficient accuracy for most purposes by taking a few readings on the upper and the lower meniscus in a clear liquid and noting the differences.

23 *Westphal Balance.* The Westphal balance is used to some extent in the determination of the specific gravity of liquids. This is a direct-reading instrument employing a small plummet and a series of weights used as riders on a graduated balance beam. This apparatus when properly calibrated is approximately of the same order of accuracy as the precision hydrometer, and has the advantage that it can be used when only small samples are available.

GAS OR VAPOR

24 Methods for determining the density of gases are discussed in detail in Bureau of Standards Technologic Papers Nos. 89 and 94.

RANGE AND ACCURACY

25 The following are the principal sources of error[10] in specific-gravity determinations by means of the picnometer or the method of hydrostatic weighing:

(*a*) Errors in weighing
(*b*) Errors in temperature measurement
(*c*) Lack of proper wetting of sample
(*d*) Lack of homogeneity of sample
(*e*) Change of volume of picnometer
(*f*) Evaporation of sample.

---

[10] Standardization of Methods for the Determination of Density, by H. W. Bearce. Proc. A.S.T.M., vol. xix, p. 412.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases Nos. 670, 671, 672, and 673, as formulated at the meeting on October 24, 1930, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 670

Inquiry: Does a vessel of shell-and-tube construction similar to a tubular boiler, which is used for the generaton of steam by means of waste gases only, and is not in direct contact with flame or fire, come within the classification of a fire-tube boiler, or can it rightfully be classified as an unfired pressure vessel?

Reply: It is the opinion of the Committee that a vessel in which steam is generated by means of waste gases, should be classed as a boiler.

CASE NO. 671

Inquiry: Is it the intent of Par. U-64 of the Code that the requirement for hydrostatic pressure tests of 50 lb. in excess of the maximum allowable working pressure for vessels that do not operate in excess of 100 lb. per sq. in., is to apply to all unfired pressure vessels regardless of size? It is pointed out that for a 21-ft.-diameter vessel to operate at 25 lb., the hydrostatic test pressure would be 3 times the working pressure, which would require an excessive thickness of shell.

Reply: Par. U-64 was formulated with general reference to pressure vessels of average size as compared with that on which the inquiry is based. For the size and type of vessel referred to, the Committee is of the opinion that the same hydrostatic test as is specified for vessels to operate in excess of 100 lb. per sq. in. should apply, and would recommend to the state authorities that they consider it on the basis of a test to $1^1/_2$ times the working pressure. A revision to this effect is under consideration.

CASE NO. 672

Inquiry: Will a low-pressure, welded, steel-plate, steam-heating boiler meet the requirements of the Code if some of the flat surfaces are braced by structural-steel shapes welded to the exterior side of the plates and the principal heating surface is formed of a number of pressed-steel diaphragm plates of $^3/_{16}$ in. thickness which have water on one side and the products of combustion on the other?

Reply: It is the opinion of the Committee that the specially formed diaphragm plates in the construction shown do not fall under the classification of "boiler plate" as specified in Par. H-11 of the Code. Flat surfaces braced by structural-steel shapes fusion welded to the exterior side of the plates will meet the requirements of the Code, provided the rules in the "Standard Practice for Making Hydrostatic Test on a Pressure Part to Determine the Maximum Allowable Working Pressure" are complied with and the boiler meets the requirements of the Code in all other respects.

Case No. 673

Inquiry: Is it the intent of the requirement in Par. P-186 of the Code, relative to the pitching of staybolts on the flat surface surrounding the firedoor opening that has been formed by flanging in the edges and butt welding, that the nearest staybolts to the opening must be arranged in a row concentric with the opening or parallel to the edges, or may the flat surface be considered as sufficiently stayed if every portion thereof up to the edge of the opening is within an area covered by striking an arc of radius equal to the allowable pitch, struck from the center of the nearest staybolt?

Reply: It is the opinion of the Committee that if every part of the area of the flat surface adjoining the firedoor opening comes within an arc of radius equal to the allowable staybolt pitch struck from the center of the nearest staybolt, the area may be considered as sufficiently stayed.

Correspondence

Contributions to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Placing Wet Concrete With Belt Conveyors

To the Editor:

The writer's attention has been called to a paper entitled "Placing Wet Concrete With Belt Conveyors," by E. L. Benson, which appeared in Vol. 52 of the Transactions of the A.S.M.E. In this paper Mr. Benson states that the first use to any extent of conveyors on a major project to handle and place concrete was on a job at Springfield, Ill., seven years ago. Without going into details, the writer would say that he brought out the ball-bearing troughing and return idlers for belt conveyors in 1906. This was really the starting point of concrete handling, because the idler in question was constructed so that neither grit, cement, nor water could get in and wear out the bearings. A special belt was then devised that would stand the scraping action of wet concrete.

In the years 1907–1910 while the new barge canal of New York State was being built, the concrete in Locks Nos. 2 and 3 at Waterford, N. Y., were constructed entirely with belt conveyors as far as the mixed concrete was concerned. After that work was done there was a period during the World War in which only small amounts of concrete were laid with belt conveyors.

In 1918 or 1919, however, work was begun on the Stamford Water Works Dam at New Canaan, Conn., the contractors being Henry Steers, Inc., of New York City. The writer designed the entire layout of conveyors, and the main dam 1900 ft. long and about 80 ft. high was laid, as far as concrete is concerned, with his company's concrete belt conveyors.

In 1921–1922 the big concrete mat for the foundations of the Western Electric Company at Kearny, N. J., on the Passaic River was built by the same contractors, and the work was done entirely with the same belt conveyors.

Perhaps the most interesting plant we ever built was one for the famous Scajaquada Creek Tunnel, one and one-half miles long through the city of Buffalo. This tunnel, 60 ft. wide and 14 ft. high, was built entirely with a moving conveyor mounted on wheels. This work was done in the years 1923–1924.

One reading the third paragraph of Mr. Benson's paper would conclude that his concern was the originator and builder of this kind of machinery. For that reason the writer believes many of his friends are right in telling him that he should except as strongly as possible in regard to the statements made in that paragraph.

B. M. Mitchell.[1]

Passaic, N. J.

To the Editor:

Referring to the comments made in Mr. Mitchell's letter, the writer would say that he made no attempt to go into the history of handling wet concrete over conveyors in his paper, as he was requested merely to prepare one covering experience in the use of portable conveyors for this purpose. All illustrations cover portable units, and reference is made to portables in preceding paragraphs as well as in the paragraph under discussion.

The writer is very sorry that the literal interpretation of one sentence permits his statement to cover so much territory. Strictly, the word "portable" should have been included, although a complete reading of the paper or the disputed paragraph should leave no doubt of the meaning, and the writer's own intent is supported by the fact that the experience of other members of his organization includes the laying of concrete considerably more than seven years ago.

The writer has no desire to infringe upon the credit properly due Mr. Mitchell for his own valuable contribution to the conveying of concrete on belts. He does not know who can safely claim the credit for being first in such use. The paper certainly makes no such claim. May the writer simply state here that the company with which he is connected is a manufacturer of conveying equipment designed especially to handle concrete, and Mr. Mitchell will possibly agree that it has aided considerably in furnishing the necessary impetus to place the conveyor in the class of a recognized standard piece of equipment for placing concrete.

E. L. Benson.[2]

Aurora, Ill.

Use of Fuel in the Manufacture of Cement

To the Editor:

Referring to paper No. FSP-52-17 of the May-August, 1930, issue of the Fuels and Steam Power Section of the A.S.M.E. Transactions, entitled "Use of Fuel in the Manufacture of Portland Cement," the writer would like to comment briefly on a test conducted in one of the largest cement plants in the country. This test was conducted on a dry process of manufacturing portland cement in a bottle-shaped rotary cement kiln, 10 × 8 × 125 ft.

The fuel-burning system used previous to this test was a storage-bin system in which the coal was dried, ground, and stored, and the operators of the plant had had years of experience with this firing arrangement. For many years past the operators have investigated unit systems of practically all types and they selected a machine known as the air-swept tube mill, which proved very successful, using the same type of coal and the same kiln as were formerly used.

---

[1] President, Conveying Weigher Company. Mem. A.S.M.E.

[2] Conveyor Division, Barber-Greene Company.

With the storage system the following important losses were found:

1 A certain amount of fuel was lost in handling from the raw coal to the ground product.

2 A certain amount of coal was required to dry the coal in a direct-indirect rotary drier.

3 Power consumption for the storage-bin system was approximately from 40 to 50 kw. per ton of coal ground.

4 Four men were used on each 12-hr. watch to take care of the grinding, handling, and firing system.

5 The maintenance cost of the storage system was approximately 15 cents per ton.

After several months' operation of the new pulverizers which fired the kiln direct, the following results were obtained in a 168-hr. test:

1 Production increased 20 per cent.

2 There were no coal losses through handling.

3 No coal loss through drying.

4 Coal was dried with preheated air which was taken from the clinker pit.

5 The power consumption was reduced to 21 kw. per ton of coal ground.

6 Only two men were required on each watch for the handling, grinding, and firing system.

7 There were no maintenance costs on the unit system for the period it had been in operation, although the guarantee of the manufacturer was 3 cents per ton for a period of years.

8 The surface moisture of the coal was as much as 8 per cent, and was dried as previously mentioned.

The writer does not wish to express the opinion that the storage system was not satisfactory in other respects, but believes that the developments of pulverized-coal unit machinery have reached such a stage that it is a matter of extreme importance to the whole portland-cement industry.

A. Gruenwald.[3]

New York, N. Y.

To the Editor:

I have read Mr. Gruenwald's discussion of my paper on "Use of Fuel in the Manufacture of Portland Cement," but there is very little that I can say in reply.

Mr. Gruenwald tells of advantages from the use of unit coal mills on cement kilns. These possibilities are pointed to in my paper. I cannot discuss relative costs because I know nothing of the actual operation of modern unit coal pulverizers on cement kilns. However, all portland-cement manufacturers are interested in such new developments, and will be glad to receive any such data as Mr. Gruenwald presents.

H. P. Reid.[4]

Chicago, Ill.

The Automatic Loom and Its Effect on Unemployment

To the Editor:

Professor Elliott Dunlap Smith, in his address at the Annual Meeting, printed in the January Mechanical Engineering, set forth most graphically the human catastrophe which has overtaken the weavers in the textile industry as the result of the development of the automatic loom:

"A weaving shed with 4000 looms that before the invention of the automatic loom would have had 4000 weavers, each tending a single loom, now may have but 40 weavers and a few unskilled helpers.

"As one weaver produced more and more textiles, more and more weavers were thrown out of work. Since the whole industry was affected, the weaver was not merely out of a job, his trade had gone."

Professor Smith then draws a contrast between two different Southern mills.

In one mill the automatic looms were put in and one worker after another was told to double the number of looms which he tended, with no attempt to "soften the blow," and a strike resulted.

In the other mill the change to the new looms was made very gradually, "so gradually that no men were laid off, the reduction in crews being effected by the normal turnover. Yet within a few years this mill was operating over 110 looms to the weaver. There was no labor hardship or unrest. During this period of technological progress, the turnover declined and the mill acquired a large waiting list of workers anxious to secure employment."

We can all agree heartily with Professor Smith that the second plan was the more humane way to make the change; and yet it left the eventual disaster to the workers from the automatic loom's introduction as great in one case as in the other.

Is it any wonder that a great army of unemployed taxes public and private charity today? The automatic loom in the textile industry is only typical of what has gone on in every other industry as a result of the work of engineers and chemists and inventors in developing labor-saving machinery and methods. No wonder the mill Professor Smith describes and every other mill has "a large waiting list of workers." One does not need to know the science of economics to see the inevitable result of this wholesale displacement of men by machines. The science of arithmetic only is needed.

Hitherto we have proceeded on the comfortable theory that the men displaced by machines would find employment in some other industry. That theory has exploded. We must face the fact, whether we like it or not, that organized society has got to find ways to employ this displaced labor, and not at starvation wages either. In order to restore prosperity we must restore the buying power of this army of unemployed.

Professor Smith's address above referred to implies that the model textile mill he describes, with its 110 looms per weaver and its higher wages and improved working conditions, was in some sense a solution of this great problem. His own reference to the "large waiting list of workers anxious to secure employment" is sufficient answer to this.

Mr. Owen D. Young calls unemployed labor "the most dangerous surplus which can exist in any country," and declares it is due to a maladjustment of our Social Machine. Col. Arthur Woods, in his address at the recent Annual Meeting, emphasized that society has got to find and repair this maladjustment. Charity to the unemployed, private or public, is absolutely necessary, but it is only an emergency measure. The only cure for unemployment is employment. Industry must furnish work for the men whom machines have replaced.

Charles Whiting Baker.[5]

New York, N. Y.

---

[3] Kennedy Van Saun Mfg. & Engrg. Corp. Assoc-Mem. A.S.M.E.

[4] Special Engineer, Universal Atlas Cement Co.

[5] Broker, Sale of Mfg. Business Properties. Past Vice-President A.S.M.E.

Engineering and Industrial Standardization

A.S.A. Elects Officers

THE election of Bancroft Gherardi, vice-president and chief engineer of the American Telephone and Telegraph Company, to the presidency of the American Standards Association was announced at the annual meeting of the Association at the Hotel Astor, New York, December 11, 1930. Cloyd M. Chapman, engineering specialist of New York City, was reelected to the vice-presidency of the association for the year 1931.

Mr. Gherardi succeeds in the presidency William J. Serrill, of the United Gas Improvement Company of Philadelphia, who has held this office since 1928.

In his report covering the work of the association during the past year, Mr. Serrill mentioned among the high spots of the year:

> Completion of 46 new national standards in the fields of mechanical, civil, chemical, and electrical engineering, and in mining, woodworking, and a number of other industries. These include a number of safety codes which are being used by regulatory bodies, insurance groups, and industry as the basis for nationally uniform methods of safeguarding the lives and health of workers.
>
> The affiliation of the following new member-bodies with the association:
>
> Institute of Radio Engineers
> Light Metals Group: Aluminum Company of America
> Manufacturers Standardization Society of the Valve and Fittings Industry
> National Coal Association
> Radio Manufacturers Association.
>
> This brings the number of organizations represented on the A.S.A. Standards Council to 45, including 9 technical societies, 29 trade associations, and 7 departments of the Federal Government.
>
> The selection of the American Standards Association by the Council of the International Standards Association for representation on the Council. The American Standards Association is one of the 18 national standardizing bodies included in the membership of the International Standards Association, which has its headquarters at Basle, Switzerland.
>
> The greatly increased financing of the work of the American Standards Association, which made possible the enlargement of the Association's technical staff.

Splines and Splined Shafts

THE formation of two technical groups of the sectional committee on small tools and machine-tool elements to formulate standards for splines and splined shafts is announced by the American Standards Association.

R. E. W. Harrison, chief engineer of the Cincinnati Grinders, Inc., will be chairman of the committee appointed to undertake the development of spline standards suitable for the machine-tool industry. Another committee under the chairmanship of W. L. Barth, standards engineer of the General Motors Corporation, will develop spline standards for the automotive and aeronautical industries.

These committees will act independently of each other, although the recommendations of both will be submitted for the approval of the general A.S.A. committee on small tools and machine-tool elements which is under the joint sponsorship of The American Society of Mechanical Engineers, the National Machine Tool Builders' Association, and the Society of Automotive Engineers. C. W. Spicer, representing the Society of Automotive Engineers, is chairman of the general committee.

Previous attempts to standardize splines have been restricted to the fitting or soft broached hole, certain factors in all spline applications having been considered too variable to permit similar standardization in the mating part, or shaft. Recently a reversal of this opinion has been observed through the standards on the subject developed by the General Motors Corporation and the British Engineering Standards Association, both of which establish definite dimensional limits for both the fitting and the shaft. The committee plans to follow this latter precedent so as to permit greater freedom in the development of the standards, and further will disregard for the present the existence of patents which might be thought to affect methods of spline manufacture.

Multiple splines of large diameters are also to be considered by the committee. It was thought, however, that consideration of these could be postponed until definite recommendations had been developed for the other types.

Standard Specifications for Sieves

THE Executive Committee of the American Society for Testing Materials has requested the American Standards Association to authorize the organization of a sectional committee to consider the adoption as American Standard certain specifications for sieves for testing purposes.

Specifications for sieves, developed in cooperation with the Bureau of Standards, were adopted by the A.S.T.M. in 1926. These specifications agree in essential requirements with the Standard Sieve Series of the Bureau of Standards. These specifications are accordingly offered for the consideration of the sectional committee.

The Bureau of Standards and the American Society for Testing Materials indicate their willingness to serve as joint sponsors for this project.

NEW AMERICAN STANDARDS

The following standards were approved by the A.S.A. during the month of December 15, 1930–January 15, 1931:

Safety Code for the Prevention of Dust Explosion in Coal Pneumatic Cleaning Plants, (Z 12f). (American Standard.)

Sponsored by the National Fire Protection Association and U. S. Department of Agriculture. Published by the National Fire Protection Association.

Woodruff Keys, Keyslots, and Cutters, (B 17f). (American Standard.)

Sponsored by The American Society of Mechanical Engineers. Published by the A.S.M.E.

Zinc Coatings on Structural Steel Shapes, Plates, and Bars and Their Products, (G 8c). (American Tentative Standard.)

Sponsored by the American Society for Testing Materials. Published by the A.S.M.E.

MECHANICAL
ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

The American Society of Mechanical Engineers

29 West 39th Street, New York

ROY V. WRIGHT, *President*
ERIK OBERG, *Treasurer* CALVIN W. RICE, *Secretary*

COMMITTEE ON PUBLICATIONS:
F. V. LARKIN, *Chairman* L. C. MORROW
W. H. WINTERROWD S. F. VOORHEES
S. W. DUDLEY
C. E. DAVIES, *Secretary to Publications Committee*

PUBLICATION STAFF:
G. A. STETSON, *Editor*
FREDERICK LASK, *Advertising Manager*

Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

BY-LAW: The Society shall not be responsible for statements or opinions advanced in papers or . . . . printed in its publications (B2, Par. 3).

A Sociologist Looks at Machines

PROF. WM. F. OGBURN, of the University of Chicago, made an address on "The Future of Man From the Sociologist's Viewpoint" before the American Society of Naturalists at its annual meeting, in Cleveland, on January 1. He called attention to a number of instances of achievement quite common today, such as heavier-than-air craft and submarines, which men prominent in science had once considered impossible. On the other hand, he pointed out, some predictions such as second-story sidewalks composed largely of translucent glass, leaving all the present street level for the use of vehicles, have not come true.

Professor Ogburn showed that the number of inventions and the rapidity of their occurrence are functions of the number of elements in existence out of which inventions and discoveries are made; and in general, inventions are not wholly replacements but additions to the total supply of elements. In other words, inventions and scientific discoveries are accumulative, and, as the pile accumulates, more and more inventions are made, since they do not appear to be restricted seriously by the limitations of human wants.

In the future environment of man, Professor Ogburn sees an increasing number of inventions and discoveries occurring with greater rapidity. This, of course, means change. Man today is dependent upon quite a variety of fabricated objects, from type writers, eyeglasses, and cigar lighters to automobiles, etc.

Professor Ogburn considers it clear that man has become more and more dependent on the smaller machines and tools, and expects that this dependency will extend with time.

Technological progress, he said, means increase in the facility of transforming the minerals and the products of the soil and the sea into objects that fulfil man's wishes. Thousands of tools now do man's work and provide these products in great quantities because of the power that can be derived from coal, oil, wind, and water. These discoveries in the use of power and new discoveries in raw materials that can be transformed into new products will bring wealth to mankind and abolish poverty.

Interstate Power

IN A REPORT made by the Federal Trade Commission to the Senate in connection with its recent investigation into interstate power transmission, figures were quoted showing that the transmission of electrical energy across state lines now amounts to 15.8 per cent of the total power generated. In addition to this a large amount of power originated in Canada and Mexico has been consumed in the United States. This raises the important question of the relation between the Federal Power Commission and the states. According to the Federal Water Power Act, where the development of water power is primarily a local problem the major responsibility belongs to the state directly concerned. But the Federal Government has the obligation of safeguarding the interests of navigation and Federal properties as they may be affected by water-power projects. In the past, there have been complaints that Federal jurisdiction was being stretched unduly. These complaints have related mostly to the cases where the Commission assumed jurisdiction over projects situated entirely on private land along non-navigable streams. The Tenth Annual Report of the Federal Power Commission explains that in these cases a considerable amount of impounding capacity has been involved, and the Commission has decided that some control over the regulation of the storage would be desirable in order to make sure that the navigable waterways lower downstream might not be deprived of such flow as required.

"Electrical Engineering"

A CHANGE in publication policy of the American Institute of Electrical Engineers has resulted in changing the name of its *Journal* to *Electrical Engineering*. The first issue under the new name appeared early last month, and a review of its contents indicates that not only has there been a change in name but also a change in format and in editorial content.

In announcing *Electrical Engineering*, William S. Lee, president of the Institute, and F. L. Hutchinson, national secretary, explain the enlarged scope of the magazine under its new and more appropriate title. *Electrical Engineering* is to include original papers on theoretical and experimental investigations, important inventions, discoveries, and developments in the fields of electrical engineering and related sciences for the purpose of supplying information that will keep the individual engineer more fully informed of developments in his field. It is also announced that more attention will be given to the effects of engineering on human relationships, and any particular influences of electrical engineering in the fields of sociology, economics, and other social sciences.

The American Institute of Electrical Engineers is to be congratulated for having taken this step in adopting a more appropriate name for its monthly journal, and at the same time in opening its pages to contributed and special articles of a less highly technical nature than those which were characteristic of the *Journal*. *Electrical Engineering* will undoubtedly become a greater force in the professional interests of electrical engineers because of this change. As we have pointed out on other occasions, the journals of engineering societies have an opportunity of performing a service that is not likely to be covered by any other type of publication.

Engineering, Economics, and Social Well-Being

ELSEWHERE in this issue will be found the addresses by Ralph E. Flanders and Wesley C. Mitchell on engineering and economics, delivered at the A.S.M.E. Annual Meeting last December. Their addresses constituted a species of friendly debate, with Dr. Magnus W. Alexander, President, National Industrial Conference Board, introducing the speakers and acting as umpire. In the performance of his task, Dr. Alexander recalled Kipling's famous lines about the Colonel's lady and Judy O'Grady who were "sisters under their skins," saying that while each speaker had marked views and experience, both were "sisters under their skins" and were working toward the social progress of the human race.

"What the engineer seeks to accomplish," said Dr. Alexander, "needs no extended treatment before this Society. I will recall only that it is primarily the function of the engineer to unfold the secrets of nature and to apply the discoveries in the field of natural science to the benefit of mankind. In no era has that function been so successfully performed as during recent decades. But there is another aspect which, while equally well known, is less well understood in its implications. I refer to the rise of large-scale industry and of mass production, brought about by the mechanization of industry and the substitution of labor-saving devices through engineering research. Industrial mechanization has made possible an increase in national wealth and income, and also a wider diffusion of the comforts of life. Living standards have been elevated, and the luxuries of the past have been transformed into the necessities of the present. Engineering has lifted the burden of drudgery from the back of the worker, reduced the fear of famine, shortened the hours of toil, and provided man with the means to enjoy his increased leisure. And the most encouraging element in the amazing economic progress provided by the engineer is that we are only on the threshold of a great social advance.

"There is, however, another side to the picture; the displacement of labor by machinery has created the problem of technological unemployment, which in the long run is solved by the development of new fields of employment opportunity, but temporarily often produces social hardships. Moreover, mechanization of industry causes enlargement of productive capacity, which, if not closely followed by corresponding consumption, creates a problem of overproduction. That problem will be solved when engineering science will have expanded consumer purchasing power as quickly and widely as it has increased producer power, and when by properly correlating the two production and consumption will be fairly balanced. Periodic maladjustment in our economic life will then be reduced to a minimum, and the 'business cycle' will lose its present disturbing significance.

"What the economist is primarily concerned with is the advancement of human welfare. He studies the disorders in the economic mechanism and the basic causes of internal friction and maladjustment. While the engineer contributes to industrial change and progress, the economist endeavors to facilitate the adjustment of the human element to that progress. His growing passion is for facts, and for conclusions based upon an unbiased interpretation of the facts.

"The economist might well profit from a practical understanding of the accomplishments of engineering; the engineer needs the broad social outlook that is derived from the study of economic problems.

"Are then the aims of the engineer and the economist opposite, or are they harmonious?

"Both the engineer and the economist are working toward the same goal—social advancement. They will the more quickly and directly travel toward that goal as they realize their affinity and work closely together as 'sisters under their skins.' A significant beginning has been made tonight. May it be followed up in a vigorous, systematic way. Beneficial results are bound to ensue for the professions of engineering and economics, and for our whole nation."

The Bethlehem-Youngstown Merger Decision

THE decision of Judge Jenkins in the case involving the Bethlehem-Youngstown merger contains some material which every engineer who may himself be a director in a corporation should know and ponder. Judge Jenkins lays down a rule that where the law or the corporation charter requires an act by a board of directors, each director must consider the action taken on its merits and must himself make such an independent investigation or such an effort to obtain the facts as would make it possible for him to form an independent judgment. If necessary, he has a right to demand that all the facts be made available to him, and he may also demand that sufficient time shall be given to him for this purpose. Where a board of directors is required to act the directors cannot waive their rights to the possession of proper facts. These rights are not personal but are representative. "It is not a question of mere majority action; it is informed action of every director, whether affirmative or negative, and qualified by investigation and knowledge to deem the consideration, terms, etc., expedient. The corporation and its shareholders are entitled to those directors' separate judgment, their arguments when fully informed, as well as those of a favorable majority." On the face of it this seems elementary; and yet it is frankly different from the common practice where two or three powerful directors determine what is to be done, and, where once it has become known that a majority in favor of an action is available, the minority seems to feel that it has nothing more to do.

Judge Jenkins also finds it objectionable for some of the directors to meet privately before the official meeting of the whole board of directors and agree among themselves on matters vitally affecting the interests of the company. He points out that such a prejudged decision renders the action of the board of directors as such less free, and that it is obviously more difficult to change the opinion of a group that has already arrived at a decision than it is to affect the opinion of individuals who come to the meeting of the board to listen and decide. It would appear, therefore, that a board of directors may err, as the law calls it, *in modo* by their method of action, even when there is no error *in re*, i.e., in the substance of their action.

Another point which is still more important for engineers is the matter of accounting. In this case two groups of accountants presented their reports, and different results appeared from these reports. The value of the opinions of experts depended on the established underlying facts, and so great a difference was found between the accounting methods of the two companies involved that to all practical purposes a reliable comparison of the two was very difficult to make. Judge Jenkins' opinion regarding the accounting problem read, in part, as follows:

> Some phases of the attempted adjustment for comparability of the two corporations, included in the accountants' ratios, were related to physical properties, manufacturing processes, and actuarial problems obviously outside of the determination of the most skilled accountants. Others were of important items for charging, for which there is no hard-and-fast accounting rule.
>
> I have been impressed in this case, as to both companies, with the divergence of accounting practices and the arbitrary technical treatment of accounting items. These have resulted here in much dif-

ficulty of understanding and in use of time, and made what should be a comparatively simple evaluation of two similar objects a complex mathematical problem of incommensurable quantities.

From this I deduce that action should be taken by cognate industries, voluntarily and not by legislative compulsion, with the cooperation of the accounting profession, to make uniform, as far as possible, their accounting practices, for purposes of setting up uniform standards of comparison of accounts, earnings and values for the guidance and necessary knowledge of directors and shareholders, as well as of investors generally.

I am further of opinion that directors, shareholders, and, incidentally, courts, should have a clear, explicit presentation of the accounting facts relating to corporations in form and language which, in accordance with common sense, will enable the ordinary reader, without hiring a technical interpreter, to determine the actual state of the corporations' business, prospects, and values. Corporate statements and reports are for the information of laymen, not of skilled accountants. Such purpose being so fulfilled, a repetition of the months spent in this case, with the use of language and schedules that not even skilled executives in the corporations involved could understand, would be done away with.

The D'Ascanio Helicopter

THE D'Ascanio helicopter, which is still in the experimental stage, is said to have already accomplished several successful flights. If the information published concerning these flights is true, we are on the eve of a very remarkable development in aerial navigation. According to the description given in a British aeronautical publication (abstracted in the Engineering Survey in this issue of Mechanical Engineering), the machine is a single seater weighing about 1750 lb. and equipped with 95-hp. engine. It has already flown in a closed circuit of 1 km., which less than thirty years ago was to be the test of the feasibility of heavier-than-air flying. It remained in the air for 8 min. 45 sec., and what is still more striking, the helicopter carried out evolutions in all directions inside the airship hangar at the Ciampino Nord Aerodrome, remaining aloft for several minutes. During some of the tests the pilot let go all controls and the machine remained perfectly steady.

Some years ago Mechanical Engineering devoted a special article to the subject of the helicopter, describing several attempts abroad as well as three American developments, among these being the Berliner machine and the one built under the direction of De-Bothezat at McCook Field, Dayton, Ohio, at the expense of the U. S. Army. Since then there have been several important attempts to solve this difficult problem, the work of Brennan of gyro monorail fame on behalf of the British Air Ministry having received particular publicity.

There is no doubt that a solution of the helicopter problem would be of tremendous importance for the art of aerial navigation. A machine that can fly in the restricted space of a hangar is truly a mechanical bird, and its ability to land within extremely restricted fields may prove to be exceedingly valuable in future development of aviation. There has been already published a statement, probably premature, that Pope Pius XI proposes to order several D'Ascanio helicopters for use by the Vatican Air Service, as the ground area available does not permit the employment of ordinary planes.

In this connection it is worth while to call attention to the progress that has been made with the autogyro, which is a transition form between the airplane and the helicopter, though lying closer to the former than to the latter. The great value of the airplane for commercial purposes is, as is well recognized today, its vital importance for military purposes; at the same time its attendant limitations are also becoming apparent. We have already learned some useful aerodynamic facts from the autogyro which appear to be applicable to the conventional airplane. If the D'Ascanio helicopter proves to be able to travel at a sufficiently high speed, it may be the very thing that the world is looking for in its quest for a three-dimensional method of transportation.

Richard Moldenke—An Appreciation

FOR more than forty years Richard Moldenke practiced as a metallurgist in the malleable-cast-iron and cast-iron foundry industries. He established himself as a recognized authority in this field, and as the highest authority in some branches of it. The personal qualities which were chiefly effective in bringing him this distinction may be described as: an unusually keen mind, tireless energy, an eager scientific curiosity, and uncompromising honesty of purpose. These attributes brought him the respect and confidence of his associates and leadership in his profession. His activities were creative and educative even to a point which limited his possibilities of personal gain, for, if he had been less generous in giving freely the results of his investigations and in raising the standards of scientific foundry practice, he could doubtless have demanded more from the industry for the services he would have been able to render. When he became executive officer of the American Foundrymen's Association, with title of secretary-treasurer, it was admittedly scarcely more than a trade organization; when he resigned fourteen years later, to devote himself to his consulting practice, the A.F.A. was a scientific society whose members wrote and discussed intelligently papers dealing with the fundamental problems of the industry in the fields of science, technology, and economics, as well as the routine details of practice. The beneficial influence of this society has penetrated to the remotest foundry on the continent, and has stimulated like results in sister organizations in foreign countries. Besides his constructive work in the A.F.A., Dr. Moldenke designed foundries and furnaces, and devised many improvements to furnaces and foundry practice. He developed methods of testing, as well as improvements in the useful properties of iron castings, and helped to develop international specifications and standards for foundry supplies and products.

Dr. Moldenke's contributions to education consisted in the dissemination of much information by means of a wide consulting practice, lively participation in meetings of several technical societies of which he was a member, the publication of researches and other monographs, and of two books, viz.: "The Principles of Iron Founding," and "The Production of Malleable Castings." He also carried a full share of work in affairs of church and state: he served on several public commissions of his home state of New Jersey, was a member of Roosevelt's Conservation Commission, investigating safety devices for mine workers throughout the country, and assisted materially in improving the metal used in the Liberty motor and other war materials during the last conflict.

His services to his profession were summed up in a recent sentence of the official publication of the American Foundrymen's Association, as follows: "No single individual has ever contributed more broadly and whole-heartedly to the improvement of foundry practice than did Dr. Moldenke."

Bradley Stoughton.[1]

A Correction

OUR attention has been called to a misstatement on page 73 of the January issue, where it was said that propeller-type turbines are being installed in connection with the development of the Dnieper River in Russia. Francis-type turbines are being installed.

---

[1] Professor of Metallurgy, Lehigh University, Bethlehem, Pa.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the Engineering Foundation, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Oil Conservation and Fuel-Oil Supply

OIL CONSERVATION AND FUEL OIL SUPPLY. A Study of International Economic Problems. The National Industrial Conference Board, Inc., New York, 1930. Cloth, 6 × 9 in., 165 pp., $2.50.

REVIEWED BY GEO. A. ORROK[1]

THIS volume has been prepared by Alfred G. White and assistants of the Conference Board's research staff under the supervision of the board's economic council, Magnus W. Alexander, president, and a large advisory committee drawn from the oil and coal industry.

The first part deals with the world sources of energy, coal, oil, gas, and water power, and the recent changes in the sources of supply. Part II deals with the supply and consumption of fuel oils, including distribution and markets. Part III treats of the same subject as confined to the United States. Part IV considers the effect of a possible decline in the fuel-oil supply. The book contains seven charts, three large maps, and an appendix with many valuable tables.

The discussion of the sources of energy, while not new, is well done and calls attention to the revolutionary changes at present taking place. The results of the "straight-run" and "cracking" refining processes are described, and the gasoline-kerosene-fuel-oil equation is discussed particularly in connection with Russian oil developments and the world market. For American conditions a very thorough study of the industrial markets is given in Part III. The work of oil conservation is given most careful consideration, as is also the effect on the fuel situation of a stationary or falling oil production. Newer practices in cracking and hydrogenation are examined, and an attempt is made to evaluate all these factors as applied to the various local markets and centers of industry. To the oil and coal producer, the refiner, the power executive, and the industrialist and business man, this report should be of great value.

Books Received in the Library

THE AIRPLANE. By Frederick Bedell and Theodore E. Thompson. Rewritten and enlarged. D. Van Nostrand Co., New York, 1930. Cloth, 6 × 9 in., 371 pp., illus., diagrams, $3.75.

This book aims to give a simple, well-rounded treatment of the principles of airplane flight which will be of use to fliers and designers, and also meet the needs of general readers. Five new chapters have been added to this edition, treating of the airplane engine, of various types of aircraft, and of instruments. The construction and equipment of the "Spirit of St. Louis" are described in detail.

A.S.T.M. TENTATIVE STANDARDS, 1930. By American Society for Testing Materials. The Society, Philadelphia, 1930. Cloth, 6 × 9 in., 864 pp., illus., diagrams, tables, $8. (Paper, $7.)

This new edition contains 155 specifications, methods of testing, etc., that have not yet been finally adopted as standard by the Society, but are under consideration and are offered for criticism. They cover the whole field of engineering materials, there being specifications for various metals, cement, clay products, preservative coatings, road materials, insulating materials, coal and coke, and various other substances.

BEITRAGE ZUR GESCHICHTE DER TECHNIK UND INDUSTRIE: Jahrbuch des Vereines Deutscher Ingenieure, Vol. 20, 1930. Edited by Conrad Matschoss. V.D.I. Verlag, Berlin, 1930. Cloth, 9 × 12 in., 221 pp., illus., portraits, 12 r.m.

Among the more important papers in this volume are: A history of the German timber-treating industry; the development of landscape photography from 1860 to 1880; oriental and Japanese steel; ancient Egyptian engineering; the history of milling; the history of brewing; and an article on an early Austrian writing machine. Other articles describe the origin and growth of various German factories and industries. There are also brief notes on minor items of historical interest, prominent engineers, technical museums and societies, and a valuable bibliography of history and biography.

A COURSE IN ENGLISH FOR ENGINEERS, Vol. 2: The Engineer's Professional and Business Writing. By Carl A. Naether and George Francis Richardson. Ginn & Co., Boston, 1930. (Engineering Series.) Cloth, 6 × 9 in., 488 pp., $3.

The second volume of this comprehensive textbook is devoted to the professional and business writing of the engineer. Everyday correspondence and sales correspondence are discussed at length; advice being given upon the composition of letters relating to orders, applications, claims, adjustments, credits, collections, quotations, etc.

DESIGN OF STEEL STRUCTURES. By Leonard Church Urquhart and Charles Edward O'Rourke. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 448 pp., illus., diagrams, tables, $5.

A companion volume to the authors' "Stresses in Simple Structures," dealing with design. After covering the fundamental topics, roof trusses and plate-girder and truss bridges are discussed. Complete designs of various types are given, with full details. As far as possible, only elementary theory is used. A chapter is devoted to welding, and standard specifications for buildings and bridges are given.

---

[1] Consulting Engineer, New York, N. Y. Mem. A.S.M.E.

Die Design and Diemaking Practice. Edited by Franklin D. Jones. Industrial Press, New York, 1930. Cloth, 6 × 9 in., 921 pp., illus., $6.

Describes current practice in making dies for blanking, forming, and drawing sheet metal, and illustrates the principles by many examples of standard and special dies. Brings together a large amount of experience that is not to be had readily elsewhere.

Elements of Mechanism. By Peter Schwamb, Allyne L. Merrill, and Walter H. James. Fourth edition. John Wiley & Sons, New York, 1930. Cloth, 6 × 9 in., 372 pp., illus., diagrams, tables, $3.50.

The new edition of this well-known text follows closely the text of the previous one, but has certain changes in arrangement, content, and treatment which have been found desirable by teachers who have used the book.

Feuerversicherung und Brandschadenabschätzung bei Maschinellen Fabrikeinrichtungen. Anhang Neuwertschierung. By Felix Moral. V.D.I. Verlag, Berlin, 1930. Paper, 6 × 8 in., 31 pp., 1 r.m.

A supplement to the author's book on factory fire insurance which appeared in 1926. This appendix discusses a new method of insuring machinery upon the basis of replacement cost instead of inventory value, and the points to be observed in applying the method.

Foundations for Human Engineering. By Charles R. Gow. Macmillan Co., New York, 1930. Cloth, 5 × 8 in., 226 pp., portraits, $1.60.

These talks, by the professor of humanics at the Massachusetts Institute of Technology, discuss social and economic problems that confront the young engineer. They give him much sound advice upon his attitude toward his employer, his associates, and his subordinates, as well as on his behavior in many other situations that arise in life.

Gusseisen: Eigenschaften und Prüfverfahren. Bericht über die Tagung des Fachausschusses für Werkstoffe in V.D.I., 28 Oktober 1929. V.D.I. Verlag, Berlin, 1930. Paper, 6 × 8 in., 96 pp., illus., Tables, 6 r.m.

A series of addresses delivered at a meeting of the Materials Division of the Society of German Engineers. The properties and structure of cast iron, the workability of various types, and the influence of various methods of cooling on the structure and resistance to wear of automobile-cylinder castings are presented, together with descriptions of the methods of mechanical testing used by various large firms. The papers present the experience of users of cast iron.

A Handbook of English in Engineering Usage. By A. C. Howell. John Wiley & Sons, New York, 1930. Cloth, 5 × 8 in., 308 pp., $2.50.

Professor Howell has compressed a great deal of definite, sensible advice within the limits of a small book. The rules of correct composition are given; grammar is reviewed briefly; punctuation is explained; and good advice is given on the composition of business letters, reports, and technical articles. The result is a very satisfactory text and reference book.

Impurities in Metals. By Colin J. Smithells. Second edition. John Wiley & Sons, New York, 1930. Paper, 6 × 10 in., 190 pp., illus., diagrams, tables, $5.

Dr. Smithells gives a systematic account of our present knowledge concerning the extent to which the structure, mechanical and electrical properties, and the corrodibility of commercial metals are affected by the impurities and minor constituents that are always present in them. He also discusses recent developments in metallographic technique, particularly in the application of X-rays to the study of the structure of metals. The new edition is thoroughly revised and considerably expanded.

Ingenieur und Wirtschaft: Der Wirtschafts-Ingenieur. By W. Prion. Julius Springer, Berlin, 1930. Paper, 6 × 10 in., 172 pp., 6 r.m.

The author, a professor of economics at the Technical High School in Berlin, here discusses the problem of proper training in economics for engineers. The inadequacies of present methods are discussed, and plans for a more useful coordination of the subjects are presented. Should interest educators.

Ingenious Mechanisms for Designers and Inventors. Edited by Franklin D. Jones. Industrial Press, New York, 1930. Cloth, 6 × 9 in., 536 pp., illus., $5.

A new collection of mechanical movements, including cams, intermittent motions, tripping and reversing mechanisms, overload mechanisms, interlocking devices, speed changes, automatic feeds, magazine feeds, and other mechanisms used in automatic and other machines. These mechanisms have been successfully used, it is stated.

Introduction to Structural Theory and Design: Theory. By Hale Sutherland and Harry Lake Bowman. John Wiley & Sons, New York, 1930. Cloth, 6 × 9 in., 318 pp., diagrams, tables, $3.50.

The basic conceptions and principles of structural theory relating to trusses, rigid frames, and space framework are presented in this text, which is planned to cover the course in stress analysis usually given in American engineering schools. Special features are the use of the bar-chain method of elastic weights for computing truss deflections, and of Professor Cross's method of rigid-frame analysis, and the presentation of a new method for approximating the wind stresses in tall-building frames.

Protection of Workers Operating Metal-Working Presses. (Studies & Reports, Series F, 2d Section, Safety No. 4.) International Labour Office, Geneva, 1930. Distributed in the U. S. by the World Peace Foundation, 40 Mt. Vernon St., Boston, Mass. Paper, 6 × 9 in., 123 pp., illus., $1.25.

Describes safety devices for various types of presses which have been found satisfactory through actual use.

Zur Frage der Beanspruchung beim Dauerschlagversuch. By Siegfried Berg. (Forschungsarbeiten, No. 331.) V.D.I. Verlag, Berlin, 1930. Paper, 9 × 12 in., 28 pp., illus., diagrams, about 5.50 r.m.

Dr. Berg's thorough investigation of stresses under repeated impact tests calls attention especially to the influence of the notch effect and the damping capacity upon stress determinations. Methods are devised for determining the notch factor and the impact factor.

Zur Kenntnis der Keramischen Eigenschaften von Kalk-Tonerde-Silikaten und Andern Feuerfesten und Hochfeuerfesten Materialien. By E. Berl and Fritz Löblein. (Forschungsarbeiten, No. 325.) V.D.I. Verlag, 1930. Paper, 9 × 12 in., 28 pp., diagrams, tables.

An investigation of the production and properties of refractory materials. Chemically pure lime-alumina silicates were investigated, particularly with reference to their heat conductivity, melting and softening points, behavior at high temperatures, and reaction to changes in temperature. Tests were also made of the principal German raw materials for refractories. The qualities of refractories are found to depend chiefly on the silica content.

Synopses of A.S.M.E. Fuels Meeting Papers

THE papers abstracted on this and the following page are to be presented at the Fourth National Meeting of the A.S.M.E. Fuels Division, held in connection with the Fifth Midwest Power Engineering Conference and the Midwestern Power and Engineering Exposition, Chicago, Ill., February 10 to 14, 1931. They discuss means of reducing plant-operating costs, producing more satisfactory results, applying new methods to old plants, and bettering the product.

Use of Oil-Refinery Waste Fuels in Modern Steam Plants. By H. J. Klotz, Assistant Chief Power Engineer, Stone and Webster Engineering Corp., Boston, Mass.

Characteristics of waste fuels are discussed and a summary is given of various methods used in burning them. A recent development is described in which the burning of these fuels is being accomplished with high-capacity mechanical atomizing burners under modern high-pressure boilers.

Economics of Fuel Utilization. By A. L. Brown, General Service Engineer, The Consolidation Coal Co., New York, N. Y.

An analysis with current statistical data is given of the relative economic values of the primary fuels: natural gas, petroleum, and coal. The paramount importance of coal as the nation's fuel, possibilities and limitations of coal-consuming equipment, and suggestions for improved coal utilization are given.

Symposium on Small Stokers. Midwest Stoker Association Paper presented by T. A. Marsh, President, Modern Coal Burner Co., Chicago, Ill.

The possibilities for use of small stokers, according to this paper, are greater than in any other field of combustion engineering. The physical problem involves the basic factors of type of stoker, fuel, and the furnace. The paper analyzes different types of small stokers and the principles used, describes various classes of furnaces, and gives operating performances and test results.

Conversion of Coal-Fired Heating Boilers and Furnaces to Gas Firing. By William D. Edwards, Mechanical Engineer, Memphis Power and Light Co., Memphis, Tenn.

The use of natural gas in the city of Memphis is discussed in this paper, and methods and data employed in making estimates of gas consumption are given. The application of the "degree-day" to this end and actual operating data for various types of plants converted to use of gas fuel are presented.

Engineering Service to Anthracite Consumers and Recent Developments in the Utilization of Anthracite. By C. A. Connell, General Manager, Anthracite Coal Service, Philadelphia, Pa.

In order to supply anthracite consumers with complete heating satisfaction, the anthracite industry, as pointed out in this paper, maintains an engineering bureau to cooperate with retail coal merchants in rendering heating service. Instruction courses in the fundamentals of heating engineering are provided to groups of dealers, and a research, developing, and testing laboratory is maintained at Anthracite Institute, in which the merits of anthracite-consuming devices are determined, and in some cases are developed further. The Anthracite Laboratory seal of approval is placed on meritorious devices.

Slag-Tap Furnaces. By Albert L. Baker, Engineer, Sargent and Lundy, Inc., Chicago, Ill.

This paper gives the experience of the author and his associates with various types of slag-tap furnaces, and presents a brief history of furnace bottoms. Troubles which have developed in operating large furnaces and the remedies applied are discussed. The effect of the slag-tap bottom on the operation of a pulverized-fuel furnace is also described, and some experimental test data are given.

Development of Pulverized-Fuel Firing. By H. Kreisinger, Consulting Engineer, Combustion Engineering Corp., New York, N. Y.

A brief review is given of the development of methods of firing pulverized fuel under steam boilers. Types and location of burners for various furnace designs are discussed, and factors are given which are most influential in producing good combustion. The author also considers the burning characteristics of various kinds of coal and how they apply when these coals are burned in pulverized form.

Recent Developments in By-Products From Bituminous Coal. By A. C. Fieldner, Chief Engineer, Experiment Stations Division, U. S. Bureau of Mines, Washington, D. C.

This paper reviews the progress in by-product recovery from bituminous coal and the value of by-products. Recent developments are described which include a new method developed by the Bureau of Mines for the determination of the gas-, coke-, and by-product-yielding properties of American coals.

Effects of Fineness of Coal Grind on Boiler Operation. By E. H. Tenney, Chief Engineer of Power Plants, Union Electric Light and Power Co., St. Louis, Mo.

The author of this paper gives a résumé of the theoretical studies and actual tests that have been made by other investigators. The factors and theory of effects of fineness of grind on the combustion of pulverized coal and design of furnaces, mills, and boiler arrangements are discussed, and the results of efficiency tests made at Cahokia with various finenesses are given.

Radiation in Boiler Furnaces. By N. Artsay, Assistant Engineer, Geo. A. Orrok, New York, N. Y.

The importance of the absorption phase of the radiant-heat-exchange problem is stressed, and it is shown that there is always an excess of radiation emission and that the controlling factor for the régime of furnace operation is in the absorbing surfaces. Formulas for total and local radiation absorption based on these assumptions are given, and the constants are determined from numerous test results. The formulas are suitable for any fuel and any type of furnace, and the trend indicated by them is said to agree with available test data.

Reduction of Unaccounted-For Losses in Boiler Tests. By W. F. Davidson, Director of Research, Brooklyn Edison Co., Brooklyn, N. Y.

The author gives a description of methods which have been developed for determining cinder loss, and includes a preliminary report on studies which are under way with a view to improving methods of flue-gas analysis. Serious discrepancies have been observed between field and laboratory determinations of CO, and an explanation of this is sought. Tests to determine the presence of unburned hydrocarbons and hydrogen are described.

The Pioneering Element in the Selection of Boiler Equipment. By F. H. Rosencrants, Consultant, International Combustion Engineering Corp., New York, N. Y.

Commercial success for any power-station development is said by the author to require the cooperation of a manufacturer and an operating organization. Those responsible desire new equipment that incorporates the best and latest practice. Pioneering efforts, in some instances, may be justified, and in others highly inadvisable.

The Boiler Room of the Future. By Geo. A. Orrok, Consulting Engineer, New York, N. Y.

The author considers the lessons that the past has taught in providing economically sound and efficient boiler rooms, and from these draws conclusions as to what may be expected as a reasonable line of future development toward the boiler room of the future.

Improvements in Missouri-Kansas Coals and Their Burning Equipment. By R. L. McDonald, Efficiency Engineer, Kansas City Power and Light Co., Kansas City, Mo.

The author discusses the gradually improved quality of Missouri-Kansas coals that has resulted from better mining methods. Operating difficulties in burning these coals and the various improvements made over a period of years to reduce these difficulties are described, and the results obtained are given.

The Fly-Ash Problem. By H. H. Bubar, President, Dust Recovery, Inc., New York, N. Y.

In this paper the author analyzes the fly-ash problem, gives characteristics of the dust, and tells what part can be claimed logically as constituting a nuisance. Various methods for decreasing the troubles are given.

Process of Dehydrating Low-Grade Coal, Especially Lignite. By Max Toltz, Consulting Engineer, St. Paul, Minn.

Low-grade coal contains great quantities of water, which makes it impossible to ship it long distances on account of freight charges and also because of its slacking when air dried. This paper describes several drying processes, including one by Dr. Fleissner, of Austria. This latter consists in first heating the coal for a certain length of time in the presence of steam at a pressure ranging from 3 to 25 atmospheres, thus preventing the escape of water from the coal, thereafter progressively reducing the pressure of the steam in order to start the drying, and continuing this reduction until the coal is dry. Another process in use at the mines at Scranton, North Dakota, and developed by Evesmith, is also described.

Accuracy Obtainable in Coal Weighing, Sampling, and Analyzing. By F. W. Martin, Statistician, Sargent and Lundy, Inc., Chicago, Ill.

This paper contains information on the accuracy of carload weighings of coal at the mine and at destination, as well as the accuracy of coal-car tare weights; the closeness with which duplicate samples of coal may be expected to check each other when analyzed in the same laboratory; the accuracy with which the same chemist may be expected to check himself on duplicate analyses of the same coal sample; and the accuracy with which different chemical laboratories may be expected to check each other.

Synopses of A.S.M.E. Transactions Papers

The papers abstracted on this and following pages appear in the current issues of Aeronautical Engineering, Applied Mechanics, Machine Shop Practice, Management, Oil and Gas Power, and Wood Industries sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced, when completed, in later issues of "Mechanical Engineering."

AERONAUTICAL ENGINEERING PAPERS

Reduction of Airplane Production Costs. By J. Don Alexander. [Paper No. AER-52-25]

The present demands for airplanes does not warrant uniform reproduction and thus many benefits of heavy production are lost. In factories operating a fairly heavy schedule, labor- and time-saving machinery can be used to advantage. This paper tells of some machine-made savings that have resulted in the factory with which the author is connected. Large economies in airplane production through use of efficient factory planing, modern machinery, and many labor-saving devices.

Airplane Design, Manufacture, and Sales, Commercial vs. Military. By Rex B. Beisel. [Paper No. AER-52-26]

The commercial industry differs materially from the military, and the paper discusses these differences from the general standpoint of design, manufacture, and sale. It would be a great deal more difficult for the commercial builder to enter the military field than for the maker of military airplanes successfully to enter the general commercial field.

The Construction and Operation of Gliders. By Gilbert G. Budwig. [Paper No. AER-52-27]

The construction, operation, and maintenance of gliders present problems for which there is little precedent. From the regulatory standpoint, the rules of the Department of Commerce will permit licensing of those built prior to October 1, 1930, by passing a satisfactory visual inspection and test. After that time, the construction of gliders will come under more severe rules for licensing.

Some Improvements in Wind-Tunnel Balances Made Possible by Use of Vacuum Tubes. By Fred S. Eastman. [Paper No. AER-52-28]

The paper presents some novel ideas on wind-tunnel balance design. It describes a new electromagnetic balance, which determines the current required to produce a balancing force. The claims are made, as against the motor-driven balance, that it is less costly, that it has no moving parts in the beam, is practically instantaneous in its response to sudden changes in force, can be quickly adjusted to almost any desired degree of sensitivity, and is readily adapted to recording devices to do away with the point-by-point method of obtaining curves.

Design and Manufacture of Airplanes From the Point of View of Low Production Costs. By Russell F. Hardy. [Paper No. AER-52-29]

The essential factors which contribute to low production costs in the manufacture of airplanes are: First, an acceptable design which will lead to quantity production; second, correct procedure with regard to designing, standardizing, experimenting, and testing; and third, efficient production methods including capable personnel, satisfactory equipment, rigid inspection, and proper routing of materials.

High-Performance Gasoline Aircraft Engine. Its Problems of Fuel, Oil, and Materials of Cylinder Construction. By S. D. Heron. [Paper No. AER-52-30]

The paper discusses the available fuels and anti-knock compounds for aircraft use. The question of the anti-knock values of widely different fuels is one concerning which but little is known. The determination of these knock values was the object of the experiments conducted.

Aluminum Alloys for Aircraft-Engine Piston and Cylinder Heads. By A. J. Lyon. [Paper No. AER-52-31]

The paper contains results of a great amount of valuable research on aluminum alloys for aircraft-engine piston and cylinder heads that has not heretofore been covered, and the findings should be valuable to all aircraft-engine designers. Two alloys have heretofore been recommended, but the Material Division at Wright Field has developed a series of new alloys, and the paper describes the method of manufacture, the effect of numerous alloying constituents on their properties, the strength at elevated temperature, their stability, and the methods of heat treatment, with comparison with the present standard alloys.

Fire-Prevention Problems. By C. G. McCord. [Paper No. AER-52-32]

This paper gives a few general principles and points out the trend of investigations that have been made along the lines of fire prevention and the design of fire extinguishers. Prevention in the case of aircraft is a relative term as there are no thoroughly satisfactory fire extinguishers, although the improvements are encouraging as more thought is being given to the subject.

While much work is in progress toward the development of aircraft fire-extinguishing systems in Government departments and by the manufacturers of that type of equipment, and although the need is manifest, there is at present no basis for a hard and fast regulation regarding the nature of equipment to be prescribed for installation in military or commercial airplanes.

THE PROBLEM OF THE PROPELLER WITH MINIMUM LOSS OF ENERGY. By Enrico Pistolesi. [Paper No. AER-52-33]

In previous papers the author has indicated the necessity of a thorough study of propeller problems, and has indicated the basis upon which such a study should be established. In his present contribution he undertakes to determine the distribution of velocity in an infinitely distant section of the slipstream which, for a given thrust, will result in a minimum loss of energy.

FLYING BOAT DESIGN. By Adolf K. Rohrbach. [Paper No. AER-52-34]

This paper tells of some of the problems encountered in designing flying boats, and compares their characteristics with those of landplanes. Five outstanding considerations include: The size of boat, aerodynamic qualities, floating system, structural principles, and general arrangement. The best shape for a flying-boat hull must be determined by experiment.

THE ARTIFICIAL HORIZON. By Elmer A. Sperry, Jr. [Paper No. AER-52-35]

This paper describes the "artificial horizon," an instrument developed recently to aid blind flying. Through the use of a gyroscope a gravity device is constructed with a very slow rate of motion that will maintain a horizontal position in an airplane with sufficient accuracy to make a most useful instrument. Test data for the instrument are given.

AIR-TRANSPORT MANAGEMENT. By D. W. Tomlinson. [Paper No. AER-52-36]

Problems which must be solved by a manager of air-transport lines are discussed in this paper. The operating department of the T.A.T.-Maddux Air Lines is divided into two groups: (1) flight and (2) engineering. The first corresponds to the operating department of a railroad, and the second takes care of inspection, maintenance, and general overhauling of equipment. There are many essentials to a well-organized air-transport company. Weather conditions must be studied and reported, radio is a necessity, and the flying force must be chosen for its keen sense of observation as well as for skill in flying. The author describes the duties of each class into which the force is divided and tells how the work is carried on with greatest success and reliability.

APPLIED MECHANICS PAPERS

THE EFFECT OF OCCASIONAL OVERSTRESS AND SUBSEQUENT ANNEALING ON CHAIN STEEL AND WELDED CHAIN STEEL. By H. Ivan Andrews. [Paper No. APM-52-11]

The results of the tests reported in this paper indicate that occasional overload tends to increase the static and fatigue strength of unwelded chain steel at the expense of the ability to resist the energy of shocks. They also indicate that the effect of annealing after overstress is to reduce the static and fatigue strength of the unwelded metal to values as low or lower than those for the metal before overstress, and that the benefit of annealing consists in the complete or partial restoration of the shock-resisting capacity of the metal.

THE STATE OF STRESS IN FULL HEADS OF PRESSURE VESSELS. By W. M. Coates. [Paper No. APM-52-12]

After a brief survey of the significant experiments upon which a comparison with the theory developed is to be based and a statement of the problem, the author derives expressions for stresses and displacements at any point of a thin-walled pressure vessel. Assuming that the shell offers no resistance to bending, an analysis is made considering it as a membrane. A study of the resulting equations indicates that in the neighborhood of the junction of head and cylinder, bending couples result, so that the plates may not be considered as membranes, at least in this locality. This leads to a consideration of the local effects of the reactions set up at the junction, the head and cylinder being considered as surfaces capable of carrying bending stresses with loads which are uniformly distributed edge-shearing forces and bending couples. The resultant effect at any point is obtained by superposition. An illustrative example is given.

TORSIONAL-VIBRATION DAMPERS. By J. P. Den Hartog and J. Ormondroyd. [Paper No. APM-52-13]

In this paper the authors present a theory of the action of friction dampers on systems in torsional resonance, with special application to gas- and Diesel-engine installations. Model tests carried out to check this theory are described. The effect of introducing springs in the Lanchester damper is also discussed.

LONGITUDINAL WAVE TRANSMISSION AND IMPACT. By L. H. Donnell. [Paper No. APM-52-14]

When a force is applied to a body, waves of stress and velocity radiate through the body from the point of application of the force. When these waves strike the boundaries of the body they may be wholly or partially transmitted to surrounding bodies or reflected back into the body, where they may reverberate back and forth within its confines like sound waves within the body of air in a closed room. By superposition of these radiated and reflected waves the stress and motion of all parts of the body are gradually, and in general discontinuously, brought up to the values ordinarily assumed.

In the case of a small body this whole process takes place so quickly that there is great difficulty in detecting it, and generally it is of little practical importance. But there are cases where it is desirable to study the process in detail, particularly when the dimensions to be dealt with are no longer very small compared to the velocities of such waves, and in consequence the time element is no longer negligible, or where the time of application or variation of applied forces is very small and hence of the same order of magnitude as the aforementioned time element, as in cases of impact or harmonic forces of considerable frequency. In the present paper an attempt is made to consider some of the more important phases of this subject in as simple a manner as possible.

STEADY FORCED VIBRATION AS INFLUENCED BY DAMPING. An Approximate Solution of the Steady Forced Vibration of a System of One Degree of Freedom Under the Influence of Various Types of Damping. By Lydik S. Jacobsen. [Paper No. APM-52-15]

In this paper the author presents a general method of obtaining approximate solutions of the steady forced vibration of a damped system of one degree of freedom for the case of sinusoidally varying disturbing forces. The approximation consists in expressing all the damping terms of the original differential equation by a single equivalent damping term, proportional to the first power of the velocity of motion.

In the case of a system influenced by a centrifugal disturbing force and damped by constant friction and by friction proportional to the first power of the velocity, experimental evidence is in good agreement with the approximate solution. While the paper deals solely with a system of one degree of freedom, there is no reason aside from complexity why the approximate solution cannot be applied to systems of several degrees of freedom.

AUTOMOTIVE BRAKES WITH SERVO-ACTION. By Dr. F. Loewenberg. [Paper No. APM-52-16]

The retardation produced in braking automotive vehicles results from the pressing of a fixed body against a moving surface. This paper discusses a method in which the friction forces themselves produce higher pressure. This has been called "self-actuation" or "self-energization." Various conditions and arrangments are discussed, and the forces developed are worked out mathematically.

ON THE MECHANICS OF THE PLASTIC STATE OF METALS. By A. Nadai. [Paper No. APM-52-17]

This paper is a study of the mechanical conditions under which plastic flow in metals occurs. Rules relative to the stresses and the deformation when the stresses reach the limit of plasticity are discussed. Some cases of plastic flow with rotational symmetry around an axis in cylinders are considered. As examples, the case of a bar in combined tension and torsion and that of a hollow cylinder subjected to a high internal pressure and axial forces are treated. The cases of pure bending of a bar with a rectangular cross-section and of pure torsion of a bar with a circular cross-section are discussed, assuming a general law of deformation. Also application of this theory is made to the hollow cylinder subjected to internal pressure. Methods of finding the residual stresses after severe plastic deformation are discussed, and the results obtained in the study should throw light on the problem of these stresses.

FURTHER RESEARCH ON HELICAL SPRINGS OF ROUND AND SQUARE WIRE. By A. M. Wahl. [Paper No. APM-52-18]

A method of calculating the stress in helical springs of square or rectangular wire is proposed. The method is to use an approximate formula, based on St. Venant's results for torsion of rectangular wire, and multiply by a correction factor based on the spring index. The method is quantitatively checked by strain measurements both on semi-coils of actual square-wire springs and on complete springs loaded in compression. It is suggested that this new formula replace those commonly given in handbooks, which may lead to considerable error in certain cases.

Deflection measurements between coils of helical round-wire tension springs made from the same bar but having spring indices varying from 2.7 to 9.5 indicate that the ordinary helical-spring formula for round wire gives results quite close to the actual deflection.

A simple approximate formula, based on St. Venant's results, for deflection of rectangular-bar springs is proposed to replace those ordinarily used and commonly given in handbooks. These ordinary deflection formulas may also lead to considerable error in certain cases.

MACHINE-SHOP PRACTICE PAPERS

What Happens When Metal Is Cut. By Orlan W. Boston. [Paper No. MSP-52-11]

The paper constitutes a valuable contribution to research and a check in some instances upon the conclusions of other authors. This study is confined mainly to deformation as seen on the exterior of the metal. It is first of several steps which may include use of the X-ray and the moving picture to reveal more exactly what is taking place as the cutting tool advances into the metal.

Some Practical Deductions From the Theory of Lubrication of Short Cylindrical Bearings. By F. E. Cardullo. [Paper No. MSP-52-12]

In this paper the author tells of desirable characteristics which a fluid lubricant should have, and explains the effects of viscosity. He develops a theory with many mathematical equations on the phenomena of longitudinal flow of lubricants in bearings. Conclusions are given regarding general design and operation of bearings, the load-carrying capacity, the power loss, and the ultimate rise in temperature of a bearing operating continuously with a particular eccentricity ratio.

Cutting Tests With Cemented-Tungsten-Carbide Lathe Tools. By T. G. Digges. [Paper No. MSP-52-13]

This investigation was made for the purpose of developing a method of testing cemented-tungsten-carbide lathe tools under heavy duty and to extend to the new cutting material some of the laws originally developed by Taylor and his associates for cutting with carbon- and high-speed-steel tools. Relations were determined between the speed, feed, depth of cut, and tool life for a selected form and size of tool. All tests were made dry in cutting 3.5 per cent nickel-steel forgings, heat-treated to give tensile strengths within the range of 85,000 to 110,000 lb. per sq. in. The results are presented in both graphic and tabular forms.

Mechanical Lapping. By Sydney Player. [Paper No. MSP-52-14]

By use of modern lapping machines it is possible to produce work that is far more accurate than the machine being used. In this paper the author discusses cylindrical and flat lapping and describes machines used and their operation. Advantages of machine lapping over other methods of finishing the surface of hardened steel are given.

Tungsten-Carbide Cutting Materials. Progress Report No. 2 of Subcommittee on Tungsten-Carbide Cutting Materials of the A.S.M.E. Special Research Committee on the Cutting of Metals. By Frank C. Spencer. [Paper No. MSP-52-15]

This analyzes about 50 replies received to questionnaires sent to over 600 users and builders of machine tools. About 75 concerns had replied at the time the report was prepared and about 50 furnished data. It is hoped that sufficient additional data will be obtained to warrant the preparation of a more complete report later.

MANAGEMENT PAPERS

Aeronautical and Automotive Service Mechanics. By A. D. Althouse. [Paper No. MAN-52-3]

This paper describes the training courses for airplane and automobile mechanics as taught at the Cass Technical High School, Detroit, Mich. They have more than doubled the minimum training requirements of airplane mechanics as set forth by the United States Department of Commerce. The course for airplane-engine mechanics includes specifications of various types and gives shop work in tuning, adjusting, and overhauling engines. The course gives skill in the use of various hand tools and also teaches technical details. Automotive training includes machine fitting, internal-combustion engines, chassis details, automotive electricity, welding, and engine testing.

Suggestions for Encouraging Education and Training for Industry. By Harold S. Falk. [Paper No. MAN-52-4]

Training of artizans and mechanics for American industry has been very much neglected in past years, and the movement for the revival of apprenticeship and industrial training can justly expect support. One of the great problems of apprenticeship and industrial training is to give the movement greater publicity, and to bring the subject before manufacturers and business men.

Local branches of the A.S.M.E. can effectively promote the movement by holding contests of various kinds related to industrial training. Because of the interest of engineers in drafting work, a contest in skill for drafting apprentices is suggested.

Such a contest may be conducted by a local committee, and if given extensive publicity will be very effective. Another possibility for the local branches is to give an award for the best paper written by an engineer on an assigned subject in the field of industrial training. The successful papers might be read before meetings of local branches of the A.S.M.E. Also local branches might award a medal or cup every year to the corporations in their respective communities which have made the greatest advance in industrial training in a given year. Such a contest might be the most effective of all, but would need to be more carefully directed than the others.

Contests of this kind could be carried on without extensive study or research, and experience in similar contests conducted under other auspices has proved that they are very effective for purposes of publicity. Through contests the influence of the A.S.M.E. would force attention to the problems of industrial training on those who are most directly concerned.

Management of Service Departments—Budgeting and Wage Incentives Applied to a Large Organization. By William B. Ferguson and Tom H. Blair. [Paper No. MAN-52-5]

The organization and the management of the service departments in a large plant with over 6000 employees doing a great variety of unstandardized work of fluctuating volume and spread over an area of 140 acres present many difficult and complicated problems in comparison with similar problems in the usual manufacturing establishment. After the productive or operative departments in the Newport News plant had been reorganized and modern methods of planning, scheduling, production control, cost control, and wage-incentive plans had been put into effect over a period of about five years, it then became possible to undertake further improvements in the staff and service departments with respect to better organization and the training of executives and employees and the measuring in some way, directly or indirectly, of the value of the service rendered or the output of these service departments; and finally the applying of bonus plans or other wage-incentive schemes to reward the employees in these service departments, with over 700 men and women, for improved efficiency. The methods described are the result of preceding study and preliminary work for over a year and represent the simplest forms of wage incentive that seemed practicable to apply to a large plant of this character.

The Training and Recruitment of Auto Mechanics Through Factory Sources. By William F. Rasche. [Paper No. MAN-52-6]

This paper treats of the selection and training of automobile mechanics through factory sources and outlines what the evolution in development of service facilities and service workers has been, what the present-day requirements are, what type of individual should be selected for training, and how a factory training school must be set up with respect to places of instruction, the preparation of a curriculum, the organization of instructional material, and the training and supervision of instructors.

Summary of the Study of Technical Institutes. By W. E. Wickenden. [Paper No. MAN-52-7]

This paper presents a highly condensed résumé of a study of a technical education above the secondary level, but of a more intensive and practical type than that offered by the four-year engineering college. The study has not included trade schools which train for skilled crafts, nor junior colleges which give the first half of a complete college course. Only terminal courses have been considered, and in general those which include in addition to technical subjects proper a substantial treatment of underlying sciences and drawing and usually some work in English and economics. The term technical institute appears to be the best common designation for the schools considered. Three rather distinct types of curricula fall within the area of the study: (1) Engineering courses which parallel the college courses in more intensive and practical forms; (2) courses in the technology of specific industries; and (3) courses preparing for particular technical functions.

Management of the Small Manufacturing Plant: Its Characteristics and Advantages. By Crosby Field. [Paper No. MAN-52-8]

Having ascertained by the four standards of comparison of size of plant that small plants greatly predominate this paper suggests two reasons for this large proportion: first, that constantly changing needs are being fulfilled by new products, requiring plants in the pioneer and expansion phases of industrial life, which plants must be relatively small; and, second, the higher efficiency that small plants seem to possess.

In order to arrive at a basis of measurement by which plants may be compared, their differences in each of their activities are evaluated in an approximate fashion, and these form a composite figure which has great influence on the plant's chances of success. Although this factor has been quite generally understood, no name has yet been given to it; hence the name "degree of uniquity" is suggested, and the effect of volume and other operating influences on this factor are discussed.

In discussing the personnel of a small plant relative versatility is stressed and also the tremendous advantage enjoyed by the small plant in having the higher incentive of part ownership for the higher executives and the immediate and concrete interrelation between effort and resulting bonuses among the subordinate keymen. General organization, research, retaining of consultants, etc., are mentioned.

Measuring Office-Machine Output as a Basis for Wage Incentives. By John Mitchell. [Paper No. MAN-52-9]

The author describes the procedure to employ in installing sound standards for office-machine work. After elimination of the unnecessary operations which a study of process sheets reveals, the various jobs are analyzed and the units in which their elements are to be measured are determined. He then takes up the determination of the value of the unit, the basis of payment and method of its calculation, the maintenance of standards set up, etc. An extensive appendix gives time allowances, rates, methods of bonus determination, and other data derived from various sources and covering a wide range of office-machine operations—addressing, typing, tabulating, duplicating, calculating, bookkeeping, etc.

Management of a Large Plant: How to Retain the Advantages of the Small Plant. By A. B. Reynders. [Paper No. MAN-52-10]

Experience shows that one man cannot efficiently supervise more than ten others. Each assistant should have definite duties and responsibilities in order to become a regular superintendent or foreman. A carefully planned organization with clearly defined duties for each position will accomplish much, but the selection of proper men is of great importance. The success of a small concern depends almost entirely upon its personnel. As the organization grows its functioning consumes more time, and a large corporation must function through written instructions. A large plant has the advantage of quantity production and can also obtain the advantages of the small plant by careful attention to details. The advantages usually considered as resulting from a small plant are quick action, low-production cost of small quantities, and close relationship of employee and employer. The paper discusses each of these advantages and outlines methods of obtaining them in large organizations.

OIL AND GAS POWER PAPERS

Joint Use of Diesel and Steam Engines to Balance Heat and Power. By Edgar J. Kates. [Paper No. OGP-52-4]

This paper deals with the use of Diesel engines in steam power plants supplying both heat and power, the purpose being to increase the efficiency of steam utilization. This is accomplished by reducing the amount of unused exhaust steam and results in lower overall costs for power and heat. The meaning of "exhaust-use factor" is illustrated by simplified examples. Similar examples are used to show the effect of Diesel power on overall thermal economy and upon overall costs.

Research of the National Advisory Committee for Aeronautics on Aircraft Diesel Engines. By Carlton Kemper. [Paper No. OGP-52-5]

The National Advisory Committee for Aeronautics has studied the theoretical performance possible with a Diesel engine operating upon a dual combustion cycle. It has investigated the great number of factors which control the injection characteristics of fuel sprays, and coordinated and applied results from test information on fuel injection and combustion to the design of combustion chambers. Considerable progress has been made.

Diesel Power-Plant Records. By M. J. Reed. [Paper No. OGP-52-6]

The advice to keep records of Diesel-engine power-plant operation has been given often, but the author here states the kinds of records that should be kept and the inferences and conclusions that may be drawn from them. No attempt is made to draw up a general or standard power-plant log, but informative data are listed so that individual operators may decide how far they may wish to go in the recording of the performances of their plants.

Results of Some Tests by Industry of Sample Diesel Fuel Oil. Progress Report No. 2 of the A.S.M.E. Special Research Committee on Diesel Fuel-Oil Specifications. [Paper No. OGP-52-7]

This committee delivered a progress report at the Annual Oil and Gas Power Convention at Pennsylvania State College in June, 1929, in which its tentative specifications as recommended for Diesel engines were reported for the first time. Oil engines were divided into two classes and designated as "heavy duty" and "light high speed." The committee advanced specifications for these oils and explained the reasons for the adoption of each item and the relative merit of the various qualities. It then sent out an appeal to the manufacturers of Diesel engines requesting that they run actual tests in engines of their design on oil meeting the maximum specifications as tentatively submitted for the two general types in order to supply it with complete information on the function of such oils.

The data presented in the report, as a result of replies received, are only preliminary, giving the operating results on the sample fuel sent out, and will serve to indicate generally how the specification fuel will operate when unheated. This and future reports will also indicate to what extent difficulties may be overcome by heating or other possible methods of handling the fuel.

Results of Further Field Tests on Suggested Diesel Fuel-Oil Specifications. Progress Report No. 3 of the A.S.M.E. Special Research Committee on Diesel Fuel-Oil Specifications. [Paper No. OGP-52-8]

Progress Report No. 2 dealt mostly with the results of various tests conducted by Diesel-engine manufacturers on the fuel designated as tentative standard specifications. Many of these tests showed unsatisfactory operation by a number of the engines when operating on the oil specified for heavy-duty engines with a maximum viscosity of 200 sec. In most cases, in meeting the viscosity specification, the various oil companies had a Conradson carbon content in excess of the suggested maximum of 4 per cent, and the difficulties encountered in operating these engines were due to carbon formation, incomplete combustion, and erratic operation, especially at low load. Consequently the committee turned its attention to the question of Conradson carbon and fluidity. This report gives data received from users and manufacturers dealing with the points mentioned.

Nitride Hardening of Alloy Steel for Diesel-Engine Use. By C. R. Alden. [Paper No. OGP-52-9]

In this paper the author discusses metallurgical developments in the nitride hardening of alloy steels and the advantages that may be expected from increased use. With correct analysis of the steel, freedom from distortion in hardening depends upon the operations preceding nitriding. A sequence of operations is given, and nitriding equipment is described. Time necessary to produce and the cost of the nitrided product are given.

Economics of the Use of Diesel Engines for Electric Power Generation. By T. A. Burdick. [Paper No. OGP-52-10]

A discussion of the application, merits, and economics of Diesel-engine generating plants for the production of electric energy for distribution and sale, together with unit, investment, and operating-cost figures, and a complete tabulation of the results obtained in three different practical solutions of a specific problem.

Report on Oil-Engine Power Cost for 1929. Submitted by the Sub-Committee on Oil-Engine Power Cost. [Paper No. OGP-52-11]

This report contains information covering 36 oil-engine plants, which submitted data sufficiently complete to permit calculation of total power-production cost. Questionnaires were sent to 106 plants, and the replies to these questionnaires are classified: Questionnaires were sent in 1929 to all plants which had submitted sufficiently complete data for the preceding period, which data were contained in last year's report.

Purification of Diesel-Engine Lubricating Oil. By A. E. Flowers and M. A. Dietrich. [Paper No. OGP-52-12]

The paper is a continuation of earlier research on a 10 by 12 Diesel engine. Its most important novelty appears to be a reference to avoiding dilution of the lubricating oil from mechanical leakage, an explicit statement upon this subject being contained in the paper. Deterioration of the lubricating oil and its increasing contamination with various substances not originally present are again shown as a function of operating power, and emphasis is placed on the large percentage of products resulting from cracking.

Power Plant and Diesel Generating Installation of R. H. Macy & Co., Inc. By George D. Pogue. [Paper No. OGP-52-13]

To meet the demand for electricity for lighting, elevators, escalators, ventilating fans, etc., in Macy's store, New York City, two Diesel-driven units each of 1000 b.hp. are used. The rates for purchased power were such that they could not be considered in comparison with a company-owned plant. The author in this paper describes the load demands and shows the advantages of Diesel-driven units in addition to steam-driven units.

Pressure Fluctuations in a Common-Rail Fuel-Injection System. By A. M. Rothrock. [Paper No. OGP-52-14]

The instantaneous pressures at the discharge orifice of a common-rail fuel-injection system were determined by analyzing the stem-lift records of an automatic injection valve. The fuel injection was obtained by releasing fuel under high pressure from a reservoir by means of a cam-operated timing valve. The period of injection was controlled by the opening of a second cam-operated valve which reduced the fuel pressure between the timing valve and the injection valve to atmospheric pressure. The results show that pressure-wave phenomena occur between the high-pressure reservoir and the injection valve, but that these pressure waves can be controlled in a manner advantageous to the injection of the fuel.

Factors in Diesel Spray-Nozzle Design in the Light of Recent Oil-Spray Research. By P. H. Schweitzer. [Paper No. OGP-52-15]

A fuel-injection system is required to deliver definite amounts of liquid in sufficiently divided sprays of suitable geometrical shape into a number of cylinders accurately timed in relation to the engine cycle. Consequently, the spray nozzle has to perform or help to perform the duties of metering, timing, injecting, and spraying. The author takes up each of these in turn and tells what oil-spray tests have indicated as desirable.

WOOD INDUSTRIES PAPERS

Airplane Spruce. By E. J. Fishbaugh. [Paper No. WDI-52-6]

The author seeks to prove that wood is a better material than metal in airplane construction where strength is required, airplane spruce being the material against which all other materials are checked for suitability. The paper indicates that airplane spruce gives the least possible weight with the greatest possible strength. There is a stand of Sitka spruce available for airplane manufacture, the author attempts to show by statistics, that will outlast the present generation of builders.

Manufacturing Upright- and Grand-Piano Cases. By Joseph T. Lindsey. [Paper No. WDI-52-7]

In this paper the author tells of the various manufacturing operations that are necessary to complete piano cases, and describes the system of following work used by the Foster-Armstrong Company. Emphasis is placed on the fact that an efficient planing system is most essential to obtain best results.

Mass Production of Radio Cabinets. By Archer W. Richards. [Paper No. WDI-52-8]

The author in this paper tells of the production methods and machinery used by the Grigsby-Grunow Company. The paper describes the plant equipment, inspection methods, plant layout, and handling methods.

NOTE: Those who have not registered in the A.S.M.E. Aeronautics, Applied Mechanics, Machine Shop Practice, Management, Oil and Gas Power, and Wood Industries Divisions whose papers are abstracted on this and the previous page, and who desire copies of any of these papers, may obtain them by using the form given below.

To the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y. Date........................

Please send copies of papers checked below:

Aeronautics [AER-52-25] [AER-52-26] [AER-52-27] [AER-52-28] [AER-52-29] [AER-52-30] [AER-52-31] [AER-52-3] [AER-52-33] [AER-52-34] [AER-52-35] [AER-52-36]

Applied Mechanics [APM-52-11] [APM-52-12] [APM-52-13] [APM-52-14] [APM-52-15] [APM-52-16] [APM-52-17] [APM-52-18]

Machine Shop Practice [MSP-52-11] [MSP-52-12] [MSP-52-13] [MSP-52-14] [MSP-52-15]

Management [MAN-52-3] [MAN-52-4] [MAN-52-5] [MAN-52-6] [MAN-52-7] [MAN-52-8] [MAN-52-9] [MAN-52-10]

Oil and Gas Power [OGP-52-4] [OGP-52-5] [OGP-52-6] [OGP-52-7] [OGP-52-8] [OGP-52-9] [OGP-52-10] [OGP-52-11] [OGP-52-12] [OGP-52-13] [OGP-52-14] [OGP-52-15]

Wood Industries [WDI-52-6] [WDI-52-7] [WDI-52-8]

PRINT name (Important)..

Street Address..City........................

Current Mechanical Engineering Literature

Selected References From The Engineering Index Service

(The Engineering Index Service Is Registered in the United States, Great Britain, and Canada by the A.S.M.E.)

THE ENGINEERING INDEX SERVICE furnishes to its subscribers a Weekly Card Index of references to the periodical literature of the world covering every phase of engineering activity, including Aeronautic, Chemical, Civil, Electrical, Management, Mechanical, Mining and Metallurgical, Naval and Marine, Railway, etc. Of the many items of particular interest to mechanical engineers a few are selected for presentation each month in this section of "Mechanical Engineering." In operating The Engineering Index Service, The American Society of Mechanical Engineers makes available the information contained in the more than 1800 technical publications received by the Engineering Societies Library (New York), thus bringing the great resources of that library to the entire engineering profession. At the end of the year all references issued by the Service are published in book form, this annual volume being known as The Engineering Index.

Photoprint copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints identify the article by quoting from the index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

AIR COMPRESSORS

High-Pressure. High-Pressure Air Compressors. Mech. World (Manchester), vol. 88, no. 2274, Aug. 1, 1930, pp. 102–103, 2 figs. Although designed particularly for use in motorships for supplying blast air for fuel-injection and air-maneuvering purposes, latest design of high-pressure air compressors built by G. and J. Weir is suitable for use also in land installations for all services where high-pressure air is required.

AIR CONDITIONING

Methods. Heating and Air Conditioning. Power, vol. 72, no. 22, Nov. 25, 1930, pp. 867–869, 2 figs. Hook-ups illustrating methods of handling air to be washed, also water circuits for air washers used for air conditioning; in industrial applications where close humidity control is necessary means for heating spray water is frequently provided; automatic control can be applied to regulate amount of air recirculated, temperature of spray, water and final air temperature.

AIRPLANE ENGINES

Cowling. The Townend Ring, H. C. H. Townend. Roy. Aeronautical Soc.—Jl (Lond.), vol. 34, no. 238, Oct. 1930, pp. 813–833 and (discussion) 833–848, 23 figs. Review of development and explanation of ring action are illustrated by sketches and graphs obtained in wind-tunnel tests with different engines and cowling arrangements; in discussion, reference is made to Thurston thumb.

Diesel. Radial Engine with Decompression Feature and Cylinder Oil-Drain Developed by Clerget. Automotive Industries, vol. 63, no. 22, Nov. 29, 1930, pp. 784–786, 4 figs. Principal features of French Clerget Diesel 9-cylinder radial airplane power plant; sketches illustrate method of operating 9 fuel pumps by cam on crankshaft and sectional view of fuel pump; rating 100 hp. at 1900 r.p.m. and 4.72 in. bore by 5.12 in. stroke; weight 462 lb., or slightly over 3 lb. per hp.

Fuels. Fuel Requirements of the Gasoline Aircraft-Engine, S. D. Heron. Soc. Automotive Engrs.—Jl., vol. 27, no. 6, Dec. 1930, pp. 694–699 and (discussion) 702–708 and 715. Fuels for use in aircraft engines are discussed with reference to their antiknock value, volatility, vapor-locking, and engine-starting properties, gum content and availability, and to antiknock agents; fuel systems should embody pressure feed of fuel by pump, suction of which is below lowest point of fuel tanks.

Knock Values of Aviation Fuels, E. E. Aldrin. Soc. Automotive Engrs.—Jl., vol. 27, no. 6, Dec. 1930, pp. 692–694 and (discussion) 702–708 and 715, 1 fig. Chart showing data based on laboratory and flight tests of aviation engines with various fuels; the better the knock rating the lower the cylinder temperature; vapor pressure is of secondary importance in its relation to vapor lock.

Supercharging. The Present Status of Aircraft Engine Superchargers, S. P. Johnston. Aviation, vol. 29, no. 6, Dec. 1930, pp. 358–359, 2 figs. Fundamental considerations in design and application of superchargers, particularly of centrifugal type, either geared or exhaust-driven supercharging equipment built by General Electric Co.

AIRPLANES

Autogiros. See AUTOGIROS.

Helicopters. See HELICOPTERS.

Maneuverability. Flight Research on Maneuverability and Spin, J. W. Crowley. Soc. Automotive Engrs. Jl., vol. 27, no. 6, Dec. 1930, pp. 665–670, 6 figs. Instruments and test methods and results at National Advisory Committee for Aeronautics; flight path and motion of airplane during spin and forces and movements acting on it; sketches illustrate design of recording accelerometer, recording turn-meter, and recording air-speed meter.

Specifications, German. German Airplane Requirements, R. M. Mock and E. Pappel. Aero Digest, vol. 17, nos. 2 and 3, Aug. 1930, pp. 82–86 and Sept. 1930, pp. 86–88, 9 figs. Aug.: General rules governing minimum requirements for principal types of plane regarding load distributions, load factors, safety factors, methods of calculation, etc. Sept.: Load factors for designing various units of landing gears; sketches illustrate forces for different landing conditions of land and seaplane.

Spinning; Characteristics. Mathematical Treatise on the Recovery From a Flat Spin, R. Fuchs. Nat. Advisory Committee Aeronautics—Tech. Memo., no. 591, Nov. 1930, pp. 1–10 and (discussion) 10–16, 5 figs. on supp. plates. Forces and moments on airplane in spin; steady spin without side wind; effect of side wind on flat spin; simple solution of basic equations; constructive measures for pulling out a flat spin; discussion contains contributions of A. King and other authorities. From Jahrbuch 1929, der Wissenschaftlichen Gesellschaft fuer Luftfahrt.

Wings, Flutter of. Practical Tests With the "Auto Control Slot," G. Lachmann. Nat. Advisory Committee for Aeronautics—Tech. Memo., nos. 593 and 594, Nov. 1930, 20 pp. and 30 pp., 39 figs. Advantages and aerodynamic characteristics of auto control slot with particular regard to gliding angle and landing speed; graph and sketches illustrate test results and layout of automatic operating mechanism; discussion relates to experiences of DVL and Focke-Wulf. Previously indexed from Zeit. fuer Flugtechnik und Motorluftschiffahrt, Aug. 28 and Sept. 15, 1930.

Wings, Metal. Metal Covering of Airplanes, J. Mather. Nat. Advisory Committee Aeronautics—Tech. Memorandums, no. 592, Nov. 1930, 15 pp., 19 figs. Experimental investigation of effect of number of corrugations of buckling and buckled plate, and résumé of principal data for experimentally tested plate beam; effect of various methods of attaching metal covering on structural strength. Translated from Jahrbuch 1929 der Wissenschaftlichen Gesellschaft fuer Luftfahrt.

Notably Light Airplane Wings of Alloy Steel Heat Treated. Iron Age, vol. 126, no. 8, Aug. 21, 1930, p. 485, 2 figs. Steel wing beams for airplanes, comparing in lightness and strength with aluminum alloy, are being fabricated on production basis by Metlab Metallurgical Laboratories, Philadelphia; beams are of Warren truss type, fabricated of chrome-molybdenum steel tubing; distortion during heat treatment of finished product has been entirely avoided by special heat-treating process used.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Bearing Metals. See AUTOMOBILES, Bearing Metals.

Chromium. See CHROMIUM ALLOYS.

ALUMINUM

Sheet. The Strength of Aluminum Alloy Sheets, J. S. Newell. Airway Age, vol. 11, and 12, Nov. 1930, pp. 1420–1424 and 1467, and Dec. pp. 1548–1551 and 1574, 22 figs. Coordination of results of tests made at Massachusetts Institute of Technology and at Stanford University with comprehensive data obtained by U. S. Bureau of Standards, Bureau of Aeronautics of Navy Department and Matèriel Division of U. S. Army Air Corps; results of shear or compressive tests on aluminum alloy sheets of thickness practicable for use in airplane structures use; of stiffeners and determination of shear strength.

ALUMINUM ALLOYS

Testing. Elastic and Resistance Characteristics of Some Light Alloys (Caratteristiche di elasticita e resistenza di alcune leghe leggere), G. Colonnetti and G. M. Pugno. Metallurgia Italiana (Milan), vol. 22, no. 13, Nov. 1930, pp. 963–966, 3 figs. Report on experimental study, made at Construction Materials Testing Laboratory of Royal School of Engineering of Turin, limited to alloys of aluminum, such as: lautal, avional, and anticorodal, and with special reference to elastic hysteresis cycles.

ASH HANDLING

Pneumatic. Striaght Line Ash Handling, R. Trautschold. Matls. Handling and Distribution, vol. 5, no. 3, Dec. 1930, pp. 34–36 and 50, 4 figs. Details of large capacity ash-handling pneumatic conveyor with steam-ejector type exhauster, washer, and silencer.

[See also STEAM POWER PLANTS.]

AUTOGIROS

Cierva. Flying the Autogiro, E. H. Alliott. Airways (Lond.), vol. 7, no. 9, Dec. 1930, pp. 555–556, 2 figs. Principal features and performance data on Cierva C. 19 Mark IIa, fitted with Genet Major engine of 100 hp.; cruising speed 76 m.p.h. and top speed 86 m.p.h.

Development. Development of the Autogiro, A. E. Larsen. Aero Digest, vol. 17, no. 4, Oct. 1930, pp. 54–56, 6 figs. Characteristics of English and American types; development of various types of rotor blades; mechanical self-starter for rotor; safety features; data on weight, pay-loads, and speed.

AUTOMOBILE ENGINES

Combustion Chambers. Development Work on Ricardo Combustion Chambers (Ueber Weiterbildungen des Ricardo-Verbrennungsraumes), H. J. Venediger. Automobiltechnische Zeit. (Berlin), vol. 33, no. 31, Nov. 10, 1930, pp. 741–744, 9 figs. Review of various combustion chambers developed from Ricardo type for purpose of improving volumetric efficiency and eliminating roughness of conventional Ricardo design; sketches illustrate latest designs of Ricardo.

Engine Knock and Anti-Knock Fuels (Le Cognement dans les moteurs, les carburants non détonants), A. Grebel. Bul. de la Société d'Encouragement (Paris), vol. 129, nos. 7-8-9, July-Aug.-Sept., 1930, pp. 624–651, 14 figs. General principles and practice of combustion-chamber design, particularly with regard to latest development, are illustrated by graphs and sketches; tables give data on composition and performance of principal types of anti-knock fuels.

AUTOMOBILES

Bearing Metals. Automobile Bearing Metals, C. Upthegrove. Am. Soc. Testing Matls. (Symposium on Developments in Automotive Materials) at mtg., Mar. 19, 1930, pp. 78–91 and (discussion) 92–102, 9 figs. Some of more dominant characteristics and factors affecting metals used as bearing metals in automobiles; factors affecting selection of bearing metal; classification; babbitt metal; bronzes. light metal-base alloys.

Brakes, Testing. Notes on Experimental Investigation of Brakes (A propos de quelques résultats expérimentaux sur le freinage), H. Petit. Technique Automobile et Aérienne (Paris) vol. 21, no. 150, 1930, pp. 65–72, 15 figs. Review of various methods of testing brake performance and evaluation of results; calculation of acceleration and methods of timing vehicles over given distance.

Springs and Suspension. Independent Suspension on Crank Axles Eliminates Variation of Wheel Tread, P. M. Heldt. Automotive Industries, vol. 63, no. 21, Nov. 22, 1930, pp. 754–756, 4 figs. Methods of using cranked stub axles capable of oscillation in vertical planes parallel to axis of vehicle; sketches illustrate front end of rear spring of Uppercu and stub axle of Uppercu coach; tubular crank arms used in Vomag truck; rear end of rear-drive Harris Leon Laisne chassis.

AUTOMOTIVE FUELS

Solid. New Considerations on Use of Carbon as Fuel for Internal-Combustion Engines (Nouvelles considérations sur l'utilisation du carbone comme combustible-carburant), A. C. Roux. Chimie et Industrie (Paris), Mar. 1930 (special no.), 1930, pp. 173–175, 1 fig.; see also brief translated abstract in Chem. Abstracts, vol. 24, no. 21, Nov. 10, 1930, p. 5459. Practical experience on road has shown practicability of use of solid fuels for automotive engines; it is suggested that producers used on vehicles be constructed with two zones, reduction being obtained by highly active, but more expensive fuel, such as charcoal, while cheaper fuel, such as powdered coal, is fed to combustion zone.

[See also AIRPLANE ENGINES, Fuels.]

B

BALANCING

Machinery. The Balancing of Machinery, C. N. Fletcher. Mech. World (Manchester), vol. 88, nos. 2287, 2288, 2289, and 2291, Oct. 31, 1930, pp. 416–417, Nov. 7, pp. 431–432, Nov. 14, pp. 464–466, Nov. 28, pp. 512–514, 18 figs. Oct. 31: Gisholt static balancer; static balancing machines; dynamic balancing equipment. Nov. 7: Krupp Losenhausen static dynamic balancing machine. Nov. 14: Krupp Lausenhausen "Universal" balancing machines; Olsen-Carwen static dynamic balancing machine. Nov. 28: Gisholt dynamic static-dynamic balancing machine; Avery patent balancing machine.

BEARINGS

Ball. Theory and Practice for Machine Parts, Especially Ball Bearings (Teori Och Praktik Vid Maskinelement, Speciellt Kullager), A. Palmgren. Teknisk Tidskrift (Stockholm), vol. 60, no. 46, Nov. 15, 1930 (Mekanik), pp. 150–152. No satisfactory theoretical formulas for dimensioning of ball bearings have yet been found; tests show that performances obtained from ball bearings sometimes deviate considerably from what was expected by theoretical computation.

Needle. Needle Bearings (Les roulements à Aiguilles), Pitner. Technique Automobile et Aérienne (Paris), vol. 21, no. 151, 1930, pp. 107–111, 7 figs. Principles of operation and design; data on load, speed, and play, etc.; application in automobile design, particularly engine and transmission are illustrated.

Needle Bearings Offer Advantages in High-Speed Automotive Engines. Automotive Industries, vol. 63, no. 24, Dec. 13, 1930, pp. 869–870, 5 figs. Principles of design and action of needle bearing; sketches illustrate typical applications with data on dimensions and load-carrying ability.

BINARY VAPOR CYCLES

Mercury-Vapor and Ammoniacate. Binary-Vapor Cycles. Power, vol. 72, no. 22, Nov. 25, 1930, pp. 830–831, 1 fig. Hook-ups for mercury-vapor and ammoniacate cycles; in both cycles heat is added to primary media at high temperature and relatively low pressure, and increase in efficiency is greater than can be obtained by superheating steam to same temperature at highest pressure now used commercially in steam turbines.

BOILERS

Dished Heads. Estimation of Dished Heads Unter Internal Superpressure Load (Beurteiluge von Gewoelbten Boeden, die durch inneren Ueberdruck belastet sind), A. Korhammer. Waerme (Berlin), vol. 53, no. 32, Aug. 9, 1930, pp. 601–605, 5 figs. Based on formulas for dished heads with internal superpressure contained in new German materials and building codes, diagrams are developed with which estimation of dished heads can be effected with sufficient accuracy.

High-Pressure. A 1000-Hour Trial on a 1700-Lb. Loeffler Boiler, H. Knodel. Engineering (Lond.), vol. 130, no. 3383, Nov. 14, 1930, pp. 632–634, 7 figs. Trial was carried out from April 9 to May 10, 1929, under supervision of Association of Boiler Owners to determine behavior of Loeffler boiler with impure feed and its reliability in service; effect of variations of load and of water level were also investigated. Abstract of paper read before Vereinigung der Grosskesselbesitzer, June 24, 1930.

The Benson Boiler at Langerbrugge. Elec. Times (Lond.), vol. 78, no. 2039, Nov. 20, 1930, pp. 881–882, 3 figs. Boiler is designed to heat water at pressure of 225 atmos. (3307 lb. per sq. in.) to a temperature of 707 deg. fahr. and then superheat it; boiler is erected out-in open, its external form is rectangular, taking up space of 15 m. by 12.1 m. (49 ft. 2 in. by 39 ft. 7 in.) and height of 32.45 m. (106 ft. 5 in.), top of chimney reaches 147 ft. 7 in.

Locomotive. See LOCOMOTIVES, Boilers.

Pulverized-Coal-Fired. Experimental Pulverized-Fuel Plant. Engineering (Lond.), vol. 130, no. 3383, Nov. 14, 1930, pp. 615–617, 4 figs. Babcock and Wilcox laid down two complete experimental plants at their Renfrew works, in one of which a three-furnace Scotch marine boiler was installed, and in other a Babcock and Wilcox marine boiler; account of this plant, with some of results obtained from it.

New Type Steam Generator Installed in Germany, H. Coerper. Combustion, vol. 2, no. 4, Oct. 1930, pp. 35–38, 6 figs. Design and operating characteristics of new steam generator installed at Hardenberg Colliery, near Dortmund, Germany; sectional elevations and plan views as well as steam-flow diagram are illustrated; chart showing rapidity of fluctuation in steam demand; pulverized fuel is introduced at four corners of furnace near bottom and is burned in zone of violent turbulence, combustion gases filling entire furnace; furnace walls are of all-metal, water-cooled type

Remodeling. Revamping Boilers Increases Capacity 60 Per Cent. Power Plant Eng., vol. 34, no. 22, Nov. 15, 1930, pp. 1273–1276, 6 figs. American Rolling Mill Co. adds water walls and new stokers to three 312-hp. boilers and increases capacity from 265 to 425 per cent rating; typical charts from new 312-b.hp. unit fired by single retort stoker; curves illustrating results of boiler tests on one of revamped units.

Tubes. Tubes for High-Pressure Water-Tube Boilers, S. F. Dorey. Mech. World (Manchester), vol. 88, nos. 2291 and 2292, Nov. 28, 1930, pp. 505–507, and Dec. 5, pp. 532–535, 9 figs. Nov. 28: Variations of maximum stress obtained by employing Haigh's strain-energy theory; calculations for 1³/₈-in., 2-in., and 3-in. diameter tubes with heat transfer rate of 80,000 B.t.u. per sq. ft. per hr. Dec. 5: Formulas are given as result of investigation to obtain heat-transmission data under conditions similar to those existing in actual water-tube boiler. Abstract of paper presented before Inst. Mar. Engrs.

BROACHING

External. Recent Developments in External Broaching, C. O. Herb. Machy. (N. Y.), vol. 37, no. 4, Dec. 1930, pp. 241–247, 9 figs. Review of tools and fixtures used in various automotive shops for finishing circular and straight surfaces of shock absorber parts; sketches show details of broaching fixtures made by Colonial Broach Co., Detroit, Mich.

C

CARS

Dynamometer. Dynamometer Car, Great Indian Peninsula. Ry. Locomotive (Lond.), vol. 36, no. 459, Nov. 15, 1930, pp. 366–367, 7 figs. partly on supp. plate. Description of car equipped with main recording department, 20 ft. long, working compartment for technical staff, 9 ft. 8 in. in length, combined day and sleeping officers' compartment, with bath room, kitchen, and tool and store room for spare equipment.

Passenger, Air Conditioning. Air Conditioning for Railway Passenger Cars, A. H. Candee. Heat, Piping and Air Conditioning, vol. 2, no. 12, Dec. 1930, pp. 1037–1043, 14 figs. Extent of air conditioning field for railway cars; basis of air conditioning; methods of cooling; location of heating and cooling units; description of B. & O. and Santa Fe diner installations.

CAST IRON

Alloy. Twenty Alloys for Gray Iron, E. K. Smith and H. C. Aufderhaar. Iron Age, vol. 126, nos. 22 and 23, Nov. 27 and Dec. 4, 1930, pp. 1583–1587 and 1688–1693, 11 figs. Nov. 27: Review of physical properties and composition of principal alloys; effect of aluminum; antimony and arsenic; bismuth and boron; calcium and cerium; cobalt; copper; lead and magnesium; manganese; molybdenum. Dec. 4: Résumé of articles showing effect of additions to gray iron of such elements as nickel, nickel and chromum, silicon, and other metals.

Bronze Welding. Repair of Cast-Iron Machine Parts by Gas Melting Process Making Use of Special Bronze (Reparaturarbeiten an Grauguszmaschinenteilen mit Hilfe des Gasschmelzverfahrens unter Verwendung von Spezialbronze), A. Glatzel. Autogene Metallbearbeitung (Halle), vol. 23, no. 20, Oct. 15, 1930, pp. 325–328, 6 figs. Methods of obtaining homogeneous and uniform weld by using special bronze; reference to work of H. Holler; examples illustrate repair of cast-iron gears and cylinders.

Heat Treatment. Oil-Hardening and Air-Hardening Cast Iron, J. E. Hurst. Foundry Trade Jl. (Lond.), vol. 43, no. 746, Dec. 4, 1930, pp. 385–386 and 395–396, 5 figs. Investigation of physical properties of alloy cast iron of nickel-chromium type regarding effect of hardening and tempering; tables and graphs interpret results and give data on composition, temperatures, hardness and tensile strength; best strength properties are developed after hardening and tempering treatment at temperature of 375 to 385 deg. cent.; microphotographs illustrate crystal structure.

CHROMIUM-NICKEL STEEL

Present Status. High-Chromium Alloy Steels; Their Present Status, E. C. Bain. Steel, vol. 87, no. 19, Nov. 6 and 13, 1930, pp. 66, 69–70 and 57–58, 62, 13 figs. Nov. 6: Influence of carbon upon structure of straight chromium alloys, in annealed and quenched conditions is illustrated by constitutional diagrams and microphotographs; alloys of low carbon and 11–13 per cent chromium composition suffice to produce resistant surface. Nov. 13: Mechanism of hardness as result of cold work; graph illustrates constitution of 18 per cent chromium alloys with varying nickel content, carbon content being negligible, and 18-8 chrome-nickel alloys with varying carbon content; microphotographs show effect of cold working on crystal structure.

COAL CARBONIZATION

Low-Temperature (Reed-Lamie Process). Hot Semi-Coke as Boiler Fuel. Power, vol. 72, no. 24, Dec. 9, 1930, pp. 941–942, 2 figs. Production of semi-coke and gas by Reed-Lamie process of low-temperature distillation is effected in revolving retort divided into series of chambers by transverse screens; loose masses of angular and spherical shapes in these chambers transmit heat to distilling mass and keep walls of retort and themselves free of carbon; results from test run on West Virginia nut and slack coal.

COAL LIQUEFACTION

Present Status. Present Status of Coal Liquefaction (Der gegenwaertige Stand der Kohleverfluessigung), L. Schuster. Dinglers Polytechnisches Jl. (Berlin), vol. 345, no. 10, Oct. 1929, pp. 184–187. Brief general description of Bergius, Fischer-Tropsch methods; Methanol-synthesis of I. G. Farben Co., and lignite high-pressure hydrogenation of same concern are discussed.

CONDENSERS, STEAM

Cooling-Water Circuits. Condensing-Water Circuits. Power, vol. 72, no. 22, Nov. 25, 1930, pp. 860–861, 1 fig. Hook-ups for six condenser circulating-water arrangements; although low-head jet condenser is indicated, high-head or multi-jet condensers could be substituted without materially affecting hook-up; similarly, two-pass condenser could be substituted for single-pass condenser shown; ejection pump of jet condenser must handle cooling water as well as condensate; in America spray ponds and cooling towers have been applied only to relatively small plants, but large installations are found abroad.

CONVEYORS

Applications. Applications and Economics of Conveyors, J. H. Hough. Soc. Automotive Engrs.—Jl., vol. 27, no. 6, Dec. 1930, pp. 646–652 and (discussion) 652–654, 9 figs. Usefulness of various types of conveying, lifting and lowering devices for factory use, with particular regard to automotive manufacturing methods; formulas for estimating maximum investment that will be profitable in mechanical-handling equipment; tables showing approximate costs of various classes and capacities of material-handling equipment.

Monorail. Lifting Device for Monorail Hoist Proves Efficient, R. S. Dart. Steel, vol. 87, no. 22, Nov. 27, 1930, pp. 50–51, 3 figs. Layout and operation of overhead monorail hoist system equipped with grab mechanism for lifting steel tote boxes; motor-operated jaws engage and disengage steel angles welded to insides of boxes at ends.

COST ACCOUNTING

Graphic Charts. Graphic Charts Best Visualize Cost Fluctuations, J. J. Berliner. Textile World, vol. 78, no. 21, Nov. 22, 1930, pp. 2464–2466, 9 figs. Preparation of chart; use of analyzing costs; examples of use.

Management and. Why Cost Accounting Is Vital to Effective Management, R. Dunkerley. Textile Recorder, vol. 48, no. 572, Nov. 15, 1930, pp. 37–38. Controlling by standards; maintenance; cost of services; control of expenses; price alterations; rationalization; problem of half-filled shop; idle time; capital turnover; selling and administration. Abstract of paper read before Inst. Cost and Works' Accountants.

Small Plants. Cost Record System for Small Plant, L. B. Brown. Power Plant Eng., vol. 34, no. 23, Dec. 1, 1930, pp. 1347–1350, 7 figs. Performance and cost record system adaptable for any small power plant; plant equipment daily log sheet; various forms used for special records.

CUPOLAS

Design. New Means of Producing High-Grade Gray Cast Iron, Chilled Castings, Malleable Iron Castings and Ingot Steel in Cupolas (Neuer Weg zur Erzeugung von Qualitaets-Grauguss, Hartguss, Temperguss und Flussstahl im Kupolofen), Lamla, Giesserei Zutung (Berlin), vol. 27, no. 22, Nov. 15, 1930, pp. 621–623, 2 figs. Design and operation of cupolas with special reference to combined shaft, bessemer and hearth furnace developed by author.

CUTTING TOOLS

Lithinit Alloy. Lithinit Cutting Metal (Das Schneidmetall "Lithinit"). Zeit fuer die Gesamte Giessereipraxis (Berlin), vol. 51, no. 45, Nov. 9, 1930 (Metall), p. 181. Lithinit in alloy composed of cobalt, tungsten, and chromium as basic metals, slight amount of iron as impurity, and addition of vanadium; metal is ready for use in cast state and needs no further heat treatment; melting point is 1250 deg.; hardness is equal to that of high-speed steel.

Testing. A Test of Machining Quality, Wallichs and Krekeler. Metallurgist (Supp. to Engineer, Lond.), Oct. 1930, pp. 149–150, 2 figs. Test by means of appliance known as Leyensetter double-pendulum simple mechanical device; results obtained in testing effect of increasing cutting speed on two steels of widely different physical properties are shown in graphs; pendulum appears to furnish delicate test of "sharpness" quality which hitherto it has not been at all easy to measure. Translated abstract of paper previously indexed from Archiv fuer das Eisenhuettenwesen, July 1930.

Tungsten Carbide. Tungsten-Carbide in the Westinghouse Plant, J. M. Highducheck. Machy. (N. Y.), vol. 37, no. 4, Dec. 1930, pp. 259–261, 3 figs. Directions for obtaining best results with new tungsten carbide cutting tools in regular machine shop practice; differences in application of tungsten carbide and high-speed steel tools; brazing tungsten-carbide tipped tools.

Tungsten Carbide for Automotive Tooling. Am. Mach., vol. 73, no. 23, Dec. 4, 1930, pp. 883–886, 7 figs. Equipment and operations in milling and boring Nash "8" cylinder block; data on feed and speeds of various machines; floor plan shows layout of cylinder block production line.

D

DESUPERHEATERS

Types and Operation. Types and Operation of Desuperheaters. Power Plant Eng., vol. 34, no. 23, Dec. 1, 1930, pp. 1351–1352, 1 fig. Closed, cartridge and spray types developed to meet requirements brought about by modern power plant practice; theoretical quantity of water required for complete desuperheating with water temperature of 200 deg. fahr.

DIESEL-ELECTRIC POWER PLANTS

Costs. A Rational Cost Basis for Diesel Power Plant Design, M. J. Reed. Diesel Power, vol. 8, no. 10, Oct. 1930, pp. 529–533, 10 figs. Rational cost basis for suitable buildings from engineering analysis; cost table of buildings for Diesel-electric generating plants in New York Metropolitan district.

DIESEL ENGINES

Automotive. British Building Automotive Heavy Oil Engine Generating 100 Hp. at 2500 R.P.M., M. W. Bourdon. Automotive Industries, vol. 63, no. 24, Dec. 13, 1930, pp. 860–864, 6 figs. Design and performance of engine built by Associated Equipment Co. of 4.33 in. bore and 5.59 in. stroke and developing 100 hp. at 2500 r.p.m.; Bosch Acro system of combustion-chamber design is used; injection pressure ranges from 1200 to 1500 lb. per sq. in. injector valve having maximum lift of only 0.050 in.

Fairbanks-Morse. New Open Combustion Chamber for Fairbanks-Morse Diesel Engines, J. Kuttner. Diesel Power, vol. 8, no. 10, Oct. 1930, pp. 524–528, 8 figs. System giving thorough combustion and improved economy based on manufacturing control; design features of chamber and spray valve; conversion of all models.

Fuel Injection. Latest Development of Solid-Fuel Injection in Diesel Engines (Neueste Entwicklung der luftlosen Brennstoffeinspritzung bei Dieselmaschinen), C. Zueblin. Werft Reederei Hafen (Berlin), vol. 11, no. 18, Sept. 22, 1930, pp. 384–389, 18 figs.; see also brief translated abstract in Mar. Engr. and Motorship Bldr. (Lond.), vol. 53, no. 638, Nov. 1930, p. 441. One of chief problems in solid injection arises from fact that atomization and distribution are somewhat opposed, the finer the atomization the less the penetrability of fuel spray; best solution of problem is adoption of accumulator-valve injection of fuel; advantages of system over ordinary fuel pump; design is suitable for all speeds.

Supercharging. Exhaust-Gas Turbine Supercharging of Diesel Engines (Abgasturbinen Aufladung bei Dieselmotoren), A. J. Buechi. Waerme (Berlin), vol. 53, no. 47, Nov. 22, 1930, pp. 878–880, 5 figs. It is shown that Diesel engines with exhaust-gas turbine supercharging with blowing in of fuel as well as with fuel spraying are superior to ordinary Diesel engines with regard to fuel economy; conditions in exhaust-gas turbo-blowers and data on scavenging air volume at different loads, showing that even with low loads, considerable scavenging takes place.

Exhaust Turbo-Blower Supercharger for Diesels, F. Johnstone-Taylor. Power Plant Eng., vol. 34, no. 23, Dec. 1, 1930, pp. 1357–1359, 4 figs. Advantages gained by use of turbo-blower for supercharging Diesel engines; results of tests showing increase of power; test results show advantage of using supercharger; pressure, temperature and heat stresses; cooling effect on cylinder walls; layout indicating method of connecting supercharger to engine.

DRILLING MACHINES

Jig Design for. Economical Utilization of Jigs and Fixtures (Wirtschaftliche Ausnutzung der Bearbeitungsvorrichtungen), F. Gruenhagen. Werkstattstechnik (Berlin), vol. 24, no. 22, Nov. 15, 1930, pp. 605–610, 16 figs. Importance of setting-up time for economy of fixtures; new methods for reducing setting-up time in mass production; merits of various types of drill jigs are illustrated by sketches.

Large. Large Drilling Machine for Steel Columns and Girders. Engineer (Lond.), vol. 150, no. 3905, Nov. 14, 1930, pp. 548–549, 4 figs. Machine drills 96 holes simultaneously and can handle members of large sectional dimensions; its special purposes are to reduce amount of handling during fabrication and to produce columns so accurately drilled that they require no reaming of rivet holes in either shop or field riveting; machine was patented by Wallace W. Smith and Vernon B. Trevellyan, operating under name of Structural Service Co., in Chicago.

Sensitive Drilling Practice. Machine Tool Operation; Sensitive Drilling Practice. Times Trade and Eng. Supp. (Lond.), vol. 27, no. 645, Nov. 15, 1930, p. 216. Methods of drilling smaller holes have been subject to notable revision during recent years; improvements cover higher spindle speeds, quicker operation of machines, and enhancement of output by better methods of handling work; driving mechanism; feed details; work-holding methods.

E

ELASTICITY

Stresses. Stresses Due to the Pressure of One Elastic Solid Upon Another, H. R. Thomas and V. A. Hoersch. Univ. Ill.—Eng. Experiment Station—Bul., vol. 27, no. 46, July 15, 1930, 56 pp., 4 figs. Review of theories and results of theoretical mathematical analysis of problem; check of mathematical solution; tests of cylinder on plane; tests of crossed cylinders; effect of various factors on calculated stresses; numerical examples.

ELECTRIC FURNACES

Forging. Ford Forges With Electric Heat. Elec. World, vol. 96, no. 20, Nov. 15, 1930, pp. 902–905, 6 figs. At present 55 electric furnaces are used for heating only comparatively small forgings as universal joint housings, front-wheel spindles, steering-gear spiders, ring gears, rear-axle shafts with forged gears on their ends, etc.; temperatures necessary for forging steel vary from 1900 to 2450 deg. fahr.; most of work in Ford plant is heated to 2300 to 2350 deg.

ELECTRIC WELDING, ARC

Atomic-Hydrogen. Atomic-Hydrogen Arc Welding According to Langmuir System (Das Arcatomschweissverfahren Lichtgogen-Schutzgasschweissung in dissoziiertem Wasserstoff nach Langmuir), S. Sandelowsky. Elektroschweissung (Braunschweig), no. 11, Nov. 1930, pp. 215–219, 12 figs. Principles and methods of system; its economic features compared with other systems; equipment developed by AEG in combination with I. G. Farbindustrie Works.

Welding With Atomic Hydrogen Process, S. Martin, Jr. Welding, vol. 1, no. 13, Nov. 1930, pp. 907–909 and 912, 7 figs. Fundamental principles and electric equipment; connection diagram for atomic-hydrogen arc-welding equipment; graph illustrates tungsten electrode consumption, average welding speed, and average welding curve for steel plates.

Testing. Army Arsenal Tests Experimental Welds, J. B. Rose. Welding, vol. 1, no. 12, Oct. 1930, pp. 832–834, 2 figs. Experimental data on physical characteristics of welds made of various plates, with various electrodes; tables give data on composition of electrode and tensile Charpy tests in foot pounds; results obtained by testing three thicknesses of structural nickel steel; tests on Upton-Lewis fatigue-testing machines.

ELECTRIC WELDING MACHINES

Butt Flash. Heavy Duty Butt Flash Welding Machines. Engineer (Lond.), vol. 150, no. 3905, Nov. 14, 1930, p. 540. Extensive trials having shown that butt welding is satisfactory for certain purposes and that quality of weld may be equal to that of solid material, method is now widely adopted in railway works, shipyards, etc.; A.E.G. of Berlin has designed machines in which clamping device is accessible on all sides and in which transformer is water cooled.

ENGINEERING RESEARCH LABORATORIES

Design. Building for Industrial Engineering Research. Eng. News-Rec., vol. 105, no. 23, Dec. 4, 1930, pp. 881–884, 6 figs. Report on design and construction of U-shaped 7-story building for engineering and research department of A. O. Smith Corp. plant at Milwaukee, Wis.; hollow columns and girders inclose air ducts and piping; laboratory has welded steel-plate floors and mechanical ventilation; large bay windows form wall areas, with aluminum pilasters and spandrels; details of trusses for floors and craneway roof.

F

FEEDWATER HEATING

Study of. A New Aspect of Feed-Water Heating, J. Andrews. Mech. World (Lond.), vol. 88, nos. 2289 and 2290, Nov. 14, 1930, pp. 467–469 and Nov. 21, pp. 479–480, 4 figs.: see also Machy. Market (Lond.), nos. 1567 and 1568 Nov. 14, 1930, pp. 21–22 and Nov. 21, pp. 21–22, 6 figs. Influence of diffusion; relative rate of heat transmission; function of live-steam feed-water heater; methods of obtaining economy; Druitt-Halpin thermal storage system. Abstract of paper presented to Instn. Engrs. and Shipbldrs. in Scotland.

FEEDWATER TREATMENT

Colloidal. Colloidal-Chemical Problems of Feedwater Treatment With Special Regard to Desiliconization (Kolloidschemische Fragen der Speisewasserbehandlung), R. Stumper. Waerme (Berlin), vol. 53, no. 46, Nov. 15, 1930, pp. 859–862, 1 fig. Application of colloidal chemistry to prevention of foaming of boiler feed and to desiliconization.

Methods. Feed-Water Treatment. Power, vol. 72, no. 22, Nov. 25, 1930, pp. 855–857, 2 figs. Hook-ups shown include not only typical examples of make-up softening, but also arrangements for reducing boiler-water impurities by deconcentration and continuous blowdown; several hook-ups show methods of recovering heat from blow-down; others show treatment of evaporator feed and methods of recovering heat from blowdown; others show treatment of evaporator feed and methods of adding acid water from zeolite softener.

FLOW METERS

Heat. Heat-Flow Meters and Thermal Conductivity Measurements, F. G. Hechler and E. R. Queer. Pa. State College Bul.—Eng. Experiment Station Series, no. 37, vol. 24, no. 38, Aug. 22, 1930, 60 pp., 30 figs. Cork board meters; with low thermal resistance; applications of guarded hot plate heater; combination of guarded plate heater and box method; applications of heat-flow meters; other applications of heat-flow meters.

FLOW OF FLUIDS

Pipes. Flow Resistance and Heat Transfer in Pipe (Ueber Stroemungswiderstand und Waermeuebergang in Rohren), S. Erk. Zeit. fuer die Gesamte Kaelte-Industrie (Berlin), vol. 37, no. 11, Nov. 9, 1930, pp. 215–218. Based on recent researches in field of flow resistance and heat transfer in pipe lines, physical significance of coefficients and values contained in equations are discussed.

FORGE SHOPS

Practice in. Mechanization of Forging Procedure (La mécanisation du travaill de forge), P. Lenormand. Arts et Métiers (Paris), vol. 83, no. 121, Oct. 1930, pp. 408–419, 8 figs. Principles of forge-shop organization with particular regard to mass production; requirements of forging-machine design and simplicity of operation; floor plan illustrates layout of machine shop.

FORGINGS

Steel. Design of Large Forgings With Particular Regard to Stretch Properties (Die Gestaltung groesserer Schmiedestuecke), A. Kaller. Maschinenbau (Berlin), vol. 9, no. 22, Nov. 20, 1930, pp. 733–736, 16 figs. Methods of controlling internal stresses by proper design, heat treatment and forging procedure are illustrated by examples taken from manufacture of shaft and rotary elements of large machinery; data on properties of chromium-nickel and chromium-nickel-molybdenum steel.

Steel Forgings in Design, L. H. Fry. Machine Design, vol. 2, no. 11, Nov. 1930, pp. 38–40 and 47, 3 figs. Review of test methods, physical properties and composition for forged steel; effect of manganese, silicon, molybdenum, nickel and chromium on forging characteristics; reference to C. McKnight's paper on Alloy Steels in Railroad Field.

FURNACES

Fuel Economy. Graphical Methods of Fuel Control, J. Cunningham. Engineering (Lond.), vol. 130, no. 3384, Nov. 21, 1930, p. 659. Investigation into furnace consumptions were undertaken with twofold purpose of establishing some basis of comparison between what had obtained in past and what might be attained, and also to find some method of rewarding furnace man for any improvement he might effect. Abstract of paper read before Inst. Fuel, Nov. 12, 1930.

FURNACES, MELTING

Pulverized-Coal. Use of Pulverized Coal Firing in German Malleable Iron Foundries (Die Anwendung der Kohlenstaubfeuerung in deutschen Tempergiessereien), R. Stotz. Giesserei (Duesseldorf), vol. 17, no. 46, Nov. 14, 1930, pp. 1112–1121, 22 figs. History of development of Brackelsberg rotary melting furnace fired with pulverized coal and stationary furnaces; requirements of pulverized coal; operating results; types of pulverized-coal-fired annealing furnaces.

G

GAGES

Limit. An Improved Limit Gage, A. Meola. Am. Mach., vol. 73, no. 21, Nov. 20, 1930, p. 823, 1 fig. Gage is of snap type; while apparently of conventional design, adjustable go and not-go anvils are rectangular instead of round, their sides being parallel to and in line with sides of fixed anvil.

Screw-Thread. See SCREW THREADS.

GEAR-CUTTING MACHINES

Helical Gears. A New Sunderland Double Helical Gear Planer. Brit. Machine Tool Eng. (Lond.), vol. 6, no. 66, Nov.-Dec. 1930, pp. 175–176, 2 figs. Machine manufactured by J. Parkinson & Son, of Shipley, is designed to cut gears up to 24 in. diam. by 4 in. face by 4 D. P.; cutters are used in pairs, one of each hand of spiral; they move alternately from edge to center of face of blank along straight guides set at angle of 30 deg., each cutter clearing way for other, when cutting continuous teeth.

GEARS

Design. Method for Exact Determination of Change Gear for Difficult Ratios (Methods zur genauen Ermittlung von Wechselraedern fuer schwierige Uebersetzungsverhaeltnisse), E. Zscherpe. Automobiltechnische Zeit. (Berlin), vol. 33, no. 33, Nov. 30, 1930, pp. 797–798. Calculation of change gears by means of endless fractions is illustrated by two examples.

Inspection Standardization. Constant Chord Gaging, S. Trimbath. Am. Mach., vol. 73. no. 20, Nov. 13, 1930, pp. 769 and 793. Methods of sizing gear teeth by means of one pair of rolls or pins per pitch, and micrometers; chart giving size for 1 diametral pitch gears with seven different pressure angles.

Reduction. See SPEED REDUCERS.

Teeth, Accuracy of. The Accuracy of Gear Teeth. Engineer (Lond.), vol. 150, no. 3904, Nov. 7, 1930, pp. 516–517, 11 figs. On behalf of H. F. L. Orcutt, of Gear Grinding Co., Birmingham, examination has been made at National Physical Laboratory of accuracy of gear wheels produced by different manufacturing methods; in one class wheels were produced by various machining processes, and were left soft or hardened after being machined; in second class they were machined, hardened and subsequently finished by grinding; effects of heat treatment are held to be most noticeable in rolled gear wheel.

Worm. Curved Forms or Shapes of Worm Threads. Machy. (N. Y.), vol. 37, no. 4, Dec. 1930, pp. 268–269. Practical advantages of curved forms of worm threads now generally used for truck and bus drives; American Gear Manufacturers' Assn. recommends 29 deg. thread ($14\frac{1}{2}$ deg. pressure angle) for single- and double-thread and 40 deg. for triple- and quadruple-thread worms; how lubrication is affected by contact between worm and wheel.

GRINDING MACHINES

Tap. Tap-Sharpening Machine. Engineering (Lond.), vol. 130, no. 3382, Nov. 7, 1930, p. 600, 3 figs. Machine for sharpening taps by grinding wheel, tap being turned about its axis while in contact with wheel, and being at same time fed toward wheel with gradually progressive motion; made by Herbert Hunt and Sons, Manchester.

H

HELICOPTERS

D'Ascanio. The D'Ascanio Helicopter. Flight (Lond.), vol. 22, no. 46, Nov. 14, 1930, p. 1249, 2 figs. Principles of single-seater, weighing about 1800 lb., and fitted with 95-hp. Fiat A.50 S engine; endurance record secured with flight of 8 min.

HYDRAULIC LABORATORIES

Holtwood, Pa. New Hydraulic Laboratory for Testing Small Model Turbines Under Actual Head Conditions, G. W. Spaulding. Baltimore Engr., vol. 5, no. 8, Nov. 1930, pp. 4–6, 3 figs. Features of three Kaplan-type turbines each having capacity of 42,500 hp. under head of 55 ft., installed for Safe Harbor Water Power Corp. development on Susquehanna River; description of Holtwood Hydraulic Laboratory, first in United States for testing turbines under actual head existing in field.

HYDRAULIC TURBINES

Draft Tubes. Cavitation in and Consequent Vibration of the Draught Tube of a Water Turbine, O. Miyagi. Soc. Mech. Engrs. Japan—Jl. (Tokyo), vol. 33, no. 2, June 1930, pp. 57–59. Theoretical consideration of governing factors of draft tubes.

Manufacture. Latest and Most Important Hydraulic Turbines and Centrifugal Pumps Manufactured in Italy (I piu recenti ed importanti impianti di turbine idrauliche e pompe centrifughe realizzati in Italia), G. Ucelli. Energia Elettrica (Milan), vol. 7, no. 10, Oct. 1930, pp. 843–860, 40 figs. General review of hydraulic equipment industry of Italy; production statistics and lists of manufacturers; characteristics of Italian turbines and pumps; methods of testing and prevention of cavitation; regulating devices; features of large installations, including dredges.

Vibrations. On the Vibration of Conical Draft-Tube of Water Turbine, S. Uchimaru and S. Kito. Tokyo Imperial Univ.—Faculty of Eng.—Jl. (Tokyo), vol. 19. no. 4, Oct. 1930, pp. 71–106, 28 figs. Experiments on flow of whirling water in conical draft-tube; ideal state of flow of whirling water in conical draft-tube; vibration of water column in conical draft-tube; boundary conditions to be satisfied by vibratory motion of water column; equation of motion for vibration of water column; approximate formula for natural frequency of vibration of water column; experiments on vibration of conical draft-tube.

HYDROELECTRIC POWER DEVELOPMENTS

Great Britain. The Lochaber Water-Power Scheme, W. T. Halcrow. Inst. Civil Engrs.—Proc. (Lond.), vol. 23, 1930, 35 pp., numerous figs. partly on supp. plates. Description of hydroelectric scheme, developed by British Aluminium Company, Ltd., in Scotland, utilizing catchment-area of 303 sq. mi., on Spey watershed; scheme involved construction of tunnel, $2\frac{3}{4}$ mi. long, connecting two lakes, also two dams from 30 to 130 ft. in height, and tunnel 15 mi. long and 15 ft. in diam.; total head is 800 ft., ultimate capacity 120,000 hp.

HYDROELECTRIC POWER PLANTS

Pumped-Storage. Hydro Hook-Ups—Pumped Storage. Power, vol. 72, no. 22, Nov. 25, 1930, pp. 846–847, 1 fig. Hydro and fuel-burning power plants are interconnected under wide variety of local conditions; certain fundamental interconnections, indicated in three diagrams; fuel-burning plants, either steam or Diesel-engine installations, are included, depending on local and other conditions that pending on local and other conditions that have an influence on equipment selection and plant design.

I

INDUSTRIAL MANAGEMENT

Stores Control. Automatic Control of Stocks and Manufactured Products (Controle automatique des approvisionnements et fabrications), Legendre. Arts et Metiers (Paris), vol. 83, no. 122, Nov. 1930, pp. 456–462, 4 figs. Simple and practical method for economic storeroom control applied by author in smaller shops, manufacturing one type of hoisting equipment which only varies with capacity and in installation requirements.

Time Study. Methods Study, K. Hathaway. Taylor Soc.—Bul., vol. 15, no. 5, Oct. 1930, pp. 210–242 and (discussion) 242–245. Fundamental principles involved in study and analysis of methods of doing work; history and development of methods-study technique; inconsistencies or violations of principle which may reduce its value and lead to difficulties; phases of methods study, and utilization of results, in which research work is needed.

Time Study in Cutting Work (L'étude des temps dans les travaux de décolletage), G. Ivanow Pratique des Industries Mecaniques (Paris), vol. 13, no. 7, Oct. 1930, pp. 265–270, 2 figs. Principles of rating with regard to determining actual cutting time and time for preparation and removal of work; tables and graphs give data for different cutting operations and various metals.

Time Study in Wood-Working Operations, M. M. Miller. Wood-Worker, vol. 49, no. 9, Nov. 1930, pp. 35–37, 6 figs. Notes and specific examples of time study operations; observation sheet for drilling operation.

INDUSTRIAL PLANTS

Design. The Relation of Safety and Design, M. J. Maryanski. Rubber Age, vol. 28, no. 3, Nov. 19, 1930, pp. 138–140, 4 figs. Problems of design engineer in planning machinery and factory layout with regard to safety of workers; safety codes must be rigidly followed; fatiguing effect of machinery; materials handling problem; special lighting problems; safety figures first in designing. Paper presented before Nat. Safety Congress.

Floors. New Type of Flooring for Workshops. Engineer (Lond.), vol. 150, no. 3906, Nov. 21, 1930, p. 577, 2 figs. Method of forming flooring of workshops, factories, etc., has been put on market by Société Anonyme des Usines, Renault, France; main constituent parts of flooring are inverted dished plates of steel of special form; all these dishes which are interchangeable are in form of octagons having four long sides and four short sides; flooring has been successfully applied for shops of various kinds, among which are included aluminum, bronze and brass foundries, drop stamp shops, and motor testing shops.

INTERNAL-COMBUSTION ENGINES

Ignition. An Investigation of the Effectiveness of Ignition Sparks, M. F. Peters, W. L. Summerville, and M. Davis. Nat. Advisory Committee for Aeronautics—Report no. 359, 1930, 13 pp., 15 figs. Methods based on measuring volume (or mass) of hydrogen and of oxygen which combines at low pressures; series spark gap may decrease or increase amount of reaction, effect depending upon amount and distribution of capacitance; differences between amount of reaction with magneto spark and ignition spark coil; determining most efficient spark generator for internal-combustion engines as well as relation between character of spark, energy, and effectiveness in igniting inflammable mixtures. Bibliography.

Indicators. A Balanced Diaphragm Type of Maximum Cylinder Pressure Indicator, J. A. Spanogle and J. H. Collins, Jr. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 359, Dec. 1930, 7 pp., 3 figs. Design and operation of maximum cylinder pressure indicator similar to Farnboro type which gives consistent results; pressure element permits location of diaphragm within $^1/_8$ in. of combustion chamber walls without water cooling; in measuring maximum explosion pressures range of pressure is read which shows variation between individual cycles; sketches illustrate arrangement of pressure element and neon tube, etc.

A New High Speed Optical Indicator, F. Nakanishi. Soc. Mech. Engrs. Japan—Jl. (Tokyo), vol. 33, no. 2, June 1930, pp. 86–87, 2 figs. Design and constructional features of indicator to be fitted directly to engine cylinder; construction is of ordinary type and some error by this vibration will enter into result but in this indicator special device was made that effect of vibration is to be cancelled.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; OIL ENGINES.]

L

LATHES

Design. Standardized Revolution Series for Lathes (Einheitliche Drehzahlreihen fuer Drehbaenke), G. Schlesinger. V.D.I. Zeit. (Berlin), vol. 74, no. 44, Nov. 1, 1930, pp. 1509–1511, 2 figs. Lead-screw drive of lathe with medium center height is treated as example to show way of finding most economical step difference for minimum number of steps, based on "tables for idling speed for machine tools and gears;" application to all types of machine tools will result in use of specific period of speed for drilling or milling machines of same size, thus realizing advantages of standardization.

LOCOMOTIVES

Boilers. Boilers of New 2-10-4 Locomotive for the Chesapeake & Ohio. Boiler Maker, vol. 30, no. 11, Nov. 1930, pp. 302–306, 7 figs. Dimensions and specifications of locomotives manufactured by Lima Locomotive Works, Inc.; design and constructional features of boiler; sectional and elevation views illustrate design features.

Design. Numerical Predetermination of Best Traveling Speed of Reciprocating Superheated Steam Locomotives of the Single Expansion Type (Ueber die rechnerische Vorausbestimmung der Guenstigsten Fahrgeschwindigkeit von Kolbenheifsdampflokomotiven einstufiger Dampfdehnung), T. Achterberg. Glasers Annalen (Berlin), vol. 107, no. 9, Nov. 1, 1930, pp. 109–113, 4 figs. Theoretical mathematical design analysis.

Diesel. Diesel Locomotive Design, J. Geiger. Ry. Engr. (Lond.), vol. 51, no. 610, Nov. 1930, pp. 425–428, 1 fig. Vibration arising from Diesel engine and from transmission system in locomotives; torsiogram for 6-cylinder Diesel-electric unit; torsional oscillations in Diesel-electric, geared-Diesel and Diesel-compressed-air locomotives. (Continuation of serial.)

4-6-2 Type Ansaldo Diesel Locomotive. Engineering (Lond.), vol. 130, no. 3384, Nov. 21, 1930, pp. 645–646, 4 figs. on p. 652. Locomotive built for Italian State Railways in which engine is direct-coupled to driving wheels; power unit is 6-cylinder Junkers Diesel engine operating on two-stroke cycle; results of trials; fuel consumption compares very favorably with average of 50 g. of coal per 100 ton-kilometers required by steam locomotive on same journey or of 30 watts required by electric locomotive.

High-Pressure. Economic Considerations on Steam Locomotives With High Temperature Drop (Wirtschaftliche Betrachtungen ueber Dampflokomotiven min erhoehtem Waermegefaelle), E. Najork and R. Wichtendahl. V.D.I. Zeit. (Berlin), vol. 74, no. 48, Nov. 29, 1930, pp. 1645–1649, 15 figs. Various systems of high-pressure locomotives recently developed are compared with 16-atmosphere standard locomotive; graphs illustrate principal thermodynamic characteristics; data on new 45-atmos. design of Hanomag.

Performance. Operating Results With the Timken Locomotive, T. V. Buckwalter. Ry. Age, vol. 89, no. 22, Nov. 29, 1930, pp. 1177–1182, 2 figs. Influence of roller-bearing locomotive on train operation indicated by 33,000 mi. of tests on three railroads; combination freight and passenger locomotive; influence of roller bearings on locomotive design; factors controlling design; roller bearing applications; experience in operation; performance in service; summary of tests; summary and deductions. Abstract of paper presented before Central Ry. Club.

LUBRICATION

Oil-Film. Oil Film Lubrication, M. H. Brillie. Engineering (Lond.), vol. 130, no. 3384, Nov. 21, 1930, p. 660. As means to obtain oil film in ordinary thrust blocks in existing bearings without using oscillating pads, new device was developed known as O. P. R. or I. N. A. system; records made by Royal Packet Navigation Co. fully confirm valuations as regards average increase in efficiency at 8 per cent; such saving is due, not to use of oscillating pads such as Michell system, but to production of oil film between parallel surfaces on O. P. R. system, adopted by Compagnie Générale Transatlantique on many of their vessels.

M

MACHINE TOOLS

Hydraulic Drive. Recent Developments in Hydraulic Drives for Machine Tools (Neueste Entwicklung der hydraulischen Antriebes von Werkzeugmaschinen). Maschinenkonstrukteur (Munich), vol. 63, nos. 18, 19, and 20, Sept. 25, 1930, pp. 364–366, Oct. 10, pp. 383–386 and Oct. 25, pp. 399–401, 213 figs. Sept. 25: Review of principles of various drives with regard to suitability and efficiency. Oct. 10: Sketches show design and operation of Hele-Shaw-Beacham, Oilgear, Sturm, Stotz, Enor, Laufthoma, Hahn & Kolb drives. Oct. 25: Installation and functioning of previously described drives in lathes and in grinding machinery.

MACHINERY

Vibrations. Eliminating Vibration in High-Speeded Machinery With Rubber Foundations, G. Rice. Rubber Age, vol. 28, no. 2, Oct. 25, 1930, pp. 85–86, 3 figs. Concrete slab on rubber foundation makes flooring for high-speed machinery that will greatly reduce and often eliminate vibrations usually accompanying heavy machinery; method of construction; advantages of rubber foundation.

MACHINING METHODS

Contour Tooling. Accurate Contour Tooling. A. L. Sinclair. Am. Mach., vol. 73, no. 20, Nov. 13, 1930, pp. 765–768, 7 figs. Production methods used by Western Electric Co. in manufacture of telephone switchboard plugs on five-spindle automatic screw machine with tungsten carbide and diamond tools; sketches illustrate automatic feeding, milling, gaging, finishing, and sizing operations.

MALLEABLE IRON CASTINGS

Corsalli Process. Low Carbon Malleable Cast Iron From the Cupola (Niedriggekohltes schmiedbares Gusseisen aus dem Kupolofen), W. Valentin. Giesserei Zeitung (Berlin), vol. 27, no. 22, Nov. 15, 1930, pp. 617–621, 6 figs. Properties of malleable iron castings; review of recent melting processes; Corsalli process for production of high-grade cast iron; results of melting in ordinary cupola and its advantages; it is claimed that malleable castings obtained would not only be on par with steel castings, but could be produced much more rapidly and cheaply.

MATERIALS HANDLING

Automobile Plants. Flexible Production System Holds Plymouth Inventory to Minimum, A. H. Paterson and J. Geschelin. Automotive Industries, vol. 63, no. 20, Nov. 15, 1930, pp. 712–716, 8 figs. Materials control system and handling equipment, with particular regard to proper planning and scheduling; principal forms of records are illustrated.

Department Stores. How Macy Handles 41,000 Packages a Day. F. A. Westbrook. Matls. Handling and Distribution, vol. 5, no. 2, Nov. 1930, pp. 25–26 and 36, 3 figs. Conveying systems used to handle packages of various sizes per day in store having world's largest volume of retail business under single roof.

Foundries. Mechanical Handling Operations in the Foundry, L. Donaldson. Rubber Age (Lond.), vol. 11, no. 9, Nov. 1930, pp. 332–336. Mechanical sand handling, handling molds and castings, handling of molten metal, pneumatic sand jet molding, model mechanized foundry, pig-iron conveyor, mechanical handling of scrap, handling iron borings, detecting faults in trucking system, use of tote boxes.

Wage-Payment Plans. The Incentive Wage System as Applied to Materials Handling, J. W. Reichenbach. Matls. Handling and Distribution, vol. 5, no. 3, Dec. 1930, pp. 17–19, and 26, 2 figs. Substantial economies from scientific time study and wage incentive plan used by Westinghouse Electric & Mfg. Co. in handling materials.

MATHEMATICS

Curve Fitting. Fitting Observations to a Curve, N. Campbell. Lond., Edinburgh, and

Dublin Philosophical Mag. and Jl. Science (Lond.), vol. 10, no. 66, Nov. 1930, pp. 745–758. Application of simplified method of curve fitting, described by Condon, Birge, and Shea, to method of zero sum; tables are given, applicable to zero sum; general considerations of problem of curve fitting.

METAL DRAWING

Deep. How to Select Thin Plate for Deep Drawing, H. T. Morton. Metal Progress, vol. 18, no. 6, Dec. 1930, pp. 54–59, 9 figs. Method of testing steel 0.250 to 0.300 in. thick, and relationship of laboratory results with records obtained simultaneously in production of roller bearing cups; data on physical properties and composition, proper method of finishing and annealing.

METAL FINISHING

Conveying Work in Process. Moving Parts Mechanically in Finishing Process, P. C. Bardin. Indus. Finishing, vol. 6, no. 12, Oct. 1930, pp. 54–56, 58 and 60, 4 figs. Specific information concerning mechanical handling and conveying equipment together with arrangement and operation to effect lower production costs in their finishing departments.

Unique Type Conveyor Developed for Oven Installation. Metal Cleaning and Finishing, vol. 2, no. 10, Oct. 1930, pp. 891–896, 12 figs. Installation for baking finish on metal furniture consists of wash tanks, dry-off oven, dip tanks and primer bake oven served by continuous conveyor of unique design, also grain, cast, and lacquer ovens.

METAL TESTING

Creep. On the Creep of Steel at Elevated Temperatures, A. Shimizu. Soc. Mech. Engrs. Japan—Jl. (Tokyo), vol. 33, no. 2, June 1930, pp. 72–79, 13 figs. Experiments show that creep deformation of low carbon steel has two periods; during first of which relative displacement of crystalloid predominates, while second crystalloid itself chiefly deforms; stress temperature and stress-life relations; empirical formulas for obtained relations.

Endurance. Vibration Strength and Creep Resistance (Schwingungsfestigkeit und Gleitwiderstand), P. Ludwik. Zeit. fuer Metallkunde (Berlin), vol. 22, no. 11, Nov. 1930, pp. 374–378, 2 figs. Relations between oscillating and static strength; changes in hardness during fatigue testing; notch tests; comparative bending tests with polished, notched and seawater-corroded non-ferrous metals; relation between prolonged bending and torsional stresses.

Failure Under Stress. On the Process of the Failure of Metals Under Stress, K. Yuasa. Soc. Mech. Engrs., Japan—Jl. (Tokyo), vol. 33, no. 2, June 1930, pp. 95–112, 55 figs. Testing and measuring apparatus which are perfectly free from inertia effect and which can automatically record real load-deformation diagrams of metals by optical method; with apparatus author carried out great many tensile, torsion and creeping test of 16 kinds of metals under various temperatures and with various speeds; also repeated tensile, stress-concentration and Fry's strain figure tests; investigation process of failure of metals under stresses, and discovery of important facts.

N

NITRIDING FURNACES

Continuous. The Development of a Continuous Nitriding Furnace, R. J. Cowan. Fuels and Furnaces, vol. 8, no. 11, Nov. 1930, pp. 1517–1520 and 1552, 7 figs. Furnace design consists of metal muffle continuous throughout furnace, fired from both sides by gas burners; second furnace consists of alloy pan conveyor type arranged to operate continuously through suitable seals; general layout of continuous nitriding furnace; curves illustrating process operation.

NOZZLES

Discharge. Some Characteristics of Fuel Sprays From Open Nozzles, A. M. Rothrock and D. W. Lee. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 356, Nov. 1930, 11 pp., 12 figs. Penetration and cone-angle of fuel sprays from open nozzles were recorded with N.A.C.A. spray photography equipment; for injection systems in which rate of pressure rise at discharge orifice is high, open nozzles give spray-tip velocities and penetrations which compare favorably with those of closed nozzles; in fuel system using open nozzles, particular care must be taken to avoid air pockets.

O

OIL ENGINES

Fuel Injection. The Benes Fuel Pump for High-Speed Oil Engines. Engineering (Lond.), vol. 130, no. 3383, Nov. 14, 1930, p. 629, 4 figs. Pump does not require special plant for its manufacture, and its production is within capacity of any firm accustomed to working within toolroom limits; both wear and leakage should be minimized by fact that pressures on side of plunger are always balanced, there being no tendency to side thrust during any portion of stroke.

OXYACETYLENE WELDING

Machines for. Gas Welding Machines in Germany, K. P. Berthold. Welding, vol. 1, no. 12, Oct. 1930, pp. 815–819, 8 figs. Design and operation of seam equipped with device which imparts oscillating motion to torch; welding machine built by Mauser Maschinenbau G.m.b.-H., Cologne-Ehrenfeld; for seam length of 8 ft.; machine for welding heavy containers, up to lengths of 19 ft. and diam. from 1 ft. to 7 ft. with sheet thickness of $^1/_4$ in. and more; curves showing feed and acetylene consumption using automatic welding machines.

P

PLANERS

Belt Drives for. Comparative Data on Planer Drives. Am. Mach., vol. 73, no. 21, Nov. 20, 1930, p. 815, 2 figs. In order to compare performance of flat belt drive from unidirectional motor with reversing pulleys, with that of V-belt drive from reversing motor, time of table travel in each direction and reversal were measured; curves show probable efficiency as represented by actual speed of travel and by theoretical, assuming no slip.

POWER PLANTS

Equipment. Draft Circuits: Fans, Economizers, Air Heaters. Power, vol. 72, no. 22, Nov. 25, 1930, pp. 858–859, 1 fig. Illustrated circuits fufill combined functions of draft production and recovery of heat in flue gases; combinations of forced and induced draft permit very slight negative pressure in furnace, ordinarily best condition, safeguarding walls and efficiency.

Steam and Diesel Combined. Diesel Power—With Steam Combination. Power, vol. 72, no. 22, Nov. 25, 1930, pp. 842–845, 3 figs. Diesel hook-ups shown range from simplest to more complex, former being more typical of current practice; for given power output Diesel receives and rejects less heat; however, methods and equipment for conserving waste heat are available wherever economic conditions justify their use.

Steam and Hydroelectric Combined. Steam and Hydro Combined for Power and Process. Power, vol. 72, no. 21, Nov. 18, 1930, pp. 786–790, 5 figs. Dalhousie plant of New Brunswick International Paper Co. is typical of interrelation of water-power development and paper industry in Canada; 6000-kw. steam turbine and 425-lb. boilers for process steam and emergency service insures reliable operation of 570-ton paper mill when hydro power is obtained over single 110-mi. transmission line; sectional elevation and principal equipment in power plant.

PRESSURE VESSELS

Longitudinally Seamless. New Process Eliminates Longitudinal Seams From Pressure Vessels. Nat. Petroleum News, vol. 22, no. 48, Nov. 26, 1930, pp. 56–58, 3 figs. Process developed by M. W. Kellogg Co. consists of manufacture of seamless steel cylinders by rolling method, and union of two or more of these cylinders into vessel of desired size by new system of automatic arc welding, which eliminated undesirable results of welding as previously practiced.

PUMPS, FEEDWATER

Design. Centrifugal Boiler Feed Pumps, D. Brownlie. Combustion, vol. 2, no. 4, Oct. 1930, pp. 43–45, 48 and 55, 6 figs. Wide adoption of centrifugal boiler feed pump follows trend of high-speed rotary auxiliaries in power-plant design; rotary pump is both inherently efficient and economical in application since either steam or electric drive may be used, choice depending on which arrangement gives best overall heat balance for station.

PULVERIZED COAL

Burners for. Powdered-Fuel Firing in Restricted Furnace Spaces, H. Nielsen. Engineering (Lond.), vol. 130, nos. 3382 and 3384, Nov. 7, 1930, pp. 573–574, and Nov. 21, pp. 638–641, 11 figs. Modern investigations have shown that large combustion chambers are not necessary, and in fact, very often they are a decided disadvantage; principles underlying proper design of pulverized-fuel burners and examples of such burners; tests carried out with new type of burner; analysis of combustion conditions; determination of fineness of pulverized coal.

R

RAIL MOTOR CARS

Gasoline. Gasoline Rail Motor Cars, Their Behavior and Influence in Operation (Benzintriebwage, Bewaehrung und Einfluss auf den Betrieb), Huebener. Verkehrstechnik (Berlin), no. 39a, Sept. 26, 1930, pp. 517–521, 4 figs. System of operation applied on Flensburg local railroad, separation of passenger and freight transportation by gasoline-operated rail motor cars by which increase in traveling speed is obtained; advantages and effect on steam operation; organization, consumption data, operating experience.

Steam. A 200 Horse-Power Steam Rail Coach. Engineer (Lond.), vol. 150, no. 3907, Nov. 28, 1930, pp. 594–595, 16 figs. One of latest types of steam rail coach is named "Phenomena;" in principle new coach follows ideas underlying design of articulated coaches for Palestine Railways and those already put in service on L.N.E. Railway; new vehicle, however, is much more powerful and has greater seating accommodation; engines are of standard Sentinel type with 6 cylinders, 6 in. in diam. by 7 in. stroke.

New "Sentinel-Cammell" Articulated Steam Rail Car, London and North Eastern Railway. Ry. Gaz. (Lond.), vol. 53, nos. 20 and 21, Nov. 14 and 21, 1930, pp. 631–633 and 668–670, 7 figs. Nov. 14: Car equipped with two 6-cylinder engines developing 200/250 hp., and special type of boiler designed to work at pressure of 300 lb. per sq. in.; engine details; transmission system; special boiler; performance data. Nov. 21: Tabular running record and other particulars of trial trip from King's Cross to Cambridge and return.

RAILROAD SIGNALS

Interlocking. Electro-Pneumatic Interlocking (Chapt. 18) of American Railway Signaling Principles and Practices, published by Signal Section, A. R. A., New York, 1930, 69 pp., 33 figs. For operation of electro-pneumatic interlocking following essential elements are necessary: supply of compressed air at pressure of from 50 to 100 lb. per sq. in.; supply of current from 12 to 16 volts, usually furnished from storage battery; interlocking machine for controlling various units; switch and signal operating mechanisms with their controlling and indicating circuits; miscellaneous units of special nature due to local conditions, such as smashboards at drawbridge, train stops, etc.; 321 questions on electro-pneumatic interlocking.

REFRIGERATING PLANTS

Design. Refrigeration Hook-Ups. Power, vol. 72, no. 22, Nov. 25, 1930, pp. 864–966, 2 figs. Hook-up diagrams illustrating various arrangements of equipment in refrigerating plant; arrangements applied to small and medium-sized plants where possible savings would not justify greater first cost or complication.

RIVETED JOINTS

Thin Plates. Riveted Joints in Thin Plates, W. Hilbes. Nat. Advisory Committee Aeronautics—Tech. Memo., no. 590, Nov. 1930, 15 pp., 9 figs. on supp. plates. Experimental investigation of stresses with particular regard to relation of plate thickness to rivet diameter; test specimen and rivets were of ultralumin, annealable, artificially aging alumin-copper-nickel alloy; closing head is formed under increasing pressure; paper and discussion give suggestions as to proper design of joints. From Jahrbuch der Wissenschaftlichen Gesellschaft fuer Luftfahrt, 1929.

ROLLS

Finishing Machines. Plate-Roll Finishing Machine. Engineering (Lond.), vol. 130, no. 3382, Nov. 7, 1930, pp. 579–582, 14 figs. partly on supp. plate. Machine manufactured by Société Anonyme des Anciens Etablissements Fetu-Defize, Liége; smaller machine is intended for finishing of rolls for mills rolling thin plates or sheets, can deal with those having maximum diam. of 2 ft. 8 in. and contact surface about 4 ft. long; in small machine action of stops is mechanically transmitted, clutch being fitted on traverse shaft; in larger machine connections are electrical.

Pressure Measurement. Measuring of Roll Pressures, F. H. Buhlmann. Iron and Steel Engr., vol. 7, no. 11, Nov. 1930, pp. 532–535, 4 figs. Operation of and results with McCullum-Peters electric telemeter and oscillograph with camera; used by Rollway Bearing Co. for loads up to 2,000,000 lb.

S

SCREW THREADS

Gages for. Application of Roll Type Thread Gages, C. V. Johnson. Machy. (N. Y.), vol. 37, no. 4, Dec. 1930, pp. 253–254, 4 figs. Advantages of roll type go and not-go thread gages manufactured by Pratt and Whitney Co.; requirements insuring interchangeability and dependability.

SPEED REDUCERS

Epicyclic Gears. Epicyclic, Gears for High Reduction Ratios, W. A. Tuplin. Mech. World (Lond.), vol. 88, nos. 2290, 2291, and 2292, Nov. 21, 1930, pp. 488–489, Nov. 28, pp. 514–516, and Dec. 5, pp. 536–537, 13 figs. Nov. 21: Basic principle upon which action of high reduction epicycle gear depends is that double spur pinion, running round inside of fixed internal gear with which one-half meshes, gives slow motion to internal gear of slightly different diameter, driven by other half; relation between pitches of internal gears; assembly of gears. Nov. 28: Method of determining gear dimensions for given duty. Dec. 5: Loads on planetary spindles and bearings; alternative arrangement; use of ball or roller bearings.

SPRINGS

Mechanism Drives. Spiral Springs for Spring-Driven Motors, E. C. Wadlow. Engineer (Lond.), vol. 150, no. 3903, Oct. 31, 1930, pp. 474–476, 8 figs. Spiral springs are widely used to provide power in motors such as are used for driving clocks, recording instruments, gramophone turntables, and similar small mechanisms; spiral spring is considered mainly from point of view of gramophone motor and following aspects are considered: effect of spring dimensions on torque available; motion of spring in barrel during unwinding; stresses; mechanical properties; energy losses; maintenance of constant speed of unwind, etc.

Railway, Design. The Design and Performance of Railway Springs, C. E. Squire. Ry. Engr. (Lond.), vol. 51, no. 610, Nov. 1930, pp. 409–413 and 429, 5 figs. Scientific study of design and operating characteristics of railway springs, as employed in construction of locomotives and rolling stock; calculation of stresses; spring failures and their causes; recording stresses; load-deflection curves.

STEAM

Cycle. The Steam Cycle, K. Baumann. Elec. Rev. (Lond.), vol. 107, no. 2764, Nov. 14, 1930, pp. 838–840, 2 figs.; see also Elec. Times (Lond.), vol. 78, no. 2038, Nov. 13, 1930, pp. 837–838, 5 figs. Considerations which are likely to affect and limit its future development. Extracts from paper read before North West Branch of Instn. of Mech. Engrs. at Manchester.

High-Pressure. Evaporation Heat of Water and Specific Volume of Saturated Steam in Range to 310 Centigrades (100,7 Atm.); (Die Verdampfungswaerme des Wassers und das spezifische Volumen von Sattdampf im Bereich bis 310 Deg. Cent. (100,7 at), M. Jakob and W. Fritz. Wissenschaftliche Abhandlungen der Physikalisch-Technischen Reichsanstalt (Berlin), vol. 14, no. 1, 1930, pp. 175–190, 2 figs. Bases for experiments and their utilization; auxiliary and principal experiments, test results and their comparison with English and American values.

Superheated, Condensation of. Temperature Distribution and Turbulence in Condensation of Superheated Steam in Pipe (Temperaturverteilung und Turbulenz beim Kondensieren von Heissdampf in einem Rohr), M. Jakob, S. Erk and H. Eck. Wissenschaftliche Abhandlungen der Physikalisch-Technischen Reichsanstalt (Berlin), vol. 14, no. 1, 1930, pp. 16–22, 8 figs. Decrease of temperature drop in condensed steam current by strong cooling of wall; elucidation of phenomena by experiment; influence of radial condensation flow on turbulence; importance of measurements of temperature and field of velocity for turbulence problem.

STEAM ACCUMULATORS

Electric Boilers and. Steam Storage and Electric Boilers. Power, vol. 72, no. 22, Nov. 25, 1930, pp. 839–841, 2 figs. Hook-ups of eight different storage systems; accumulator in most installations serves three main purposes: first, to reduce required boiler capacity; second, to permit more even operation of boilers with resulting higher efficiency; and third (where by-product power is generated) to permit maximum generation of such power, or, conversely, maximum utilization of exhaust steam, where steam and power loads do not correspond.

Kiesselbach System. The Kiesselbach Feed Water Storage System. Engineering (Lond.), vol. 130, no. 3384, Nov. 21, 1930, pp. 643–644, 3 figs. partly on supp. plate. Essentials of system are storage tank and circulating pump, latter being in continuous operation; on suction side this pump is connected to storage tank and supplies water to boiler through circulating pipe; boiler can be operated at its maximum efficiency while, notwithstanding fluctuations in steam demand, firing can be maintained at constant rate for several hours, without any drop in pressure occurring; installation of system at Fuerst Hardenberg mine of Vereinigte Stahlwerke.

STEAM CONDENSERS

Heat Transmission in. Heat Transfer From Condensing Steam to Flowing Water Through Single Metal Tubes Completely Surrounded by Air-Free Steam, A. T. Brown. Combustion, vol. 2, no. 4, Oct. 1930, pp. 26–30, 6 figs. Method for correlating known experimental data as determined by various authorities covering rates of heat transmission through single metal tubes completely surrounded by air-free steam; comparison with actual performance.

The Coefficients of Heat Transfer From Tube to Water, A. Eagle and R. M. Ferguson. Engineer (Lond.), vol. 150, no. 3907, Nov. 28, 1930, pp. 605–606, and (discussion), p. 596, 3 figs. Results of research with object of determining way in which coefficient of heat transfer varies with physical properties of fluids employed; research in first instance was confined to determining phenomena on water side of condenser tube. Abstract of report to Instn. Mech. Engrs. received from Brit. Elec. and Allied Industries Research Assn.

STEAM-ELECTRIC POWER PLANTS

Great Britain. The Battersea Station of the London Power Company. Engineering (Lond.), vol. 130, no. 3383, Nov. 14, 1930, p. 628. Ultimate designed capacity is 400,000 kw., but buildings now under construction will only accommodate half that amount; steam-raising plant of nine units, each with maximum output of 330,000 lb. steam per hr. at pressure of 650 lb. per sq. in. and temperature of 900 deg. fahr.; turbines of 3-cylinder type, with double-flow low-pressure cylinder exhausting into two condensers, will each drive main and auxiliary alternator; three-phase energy will be generated at 11,000 volts by main alternator.

The Equipment of Dunston B Power Station. Engineering (Lond.), vol. 130, no. 3381, Oct. 31, 1930, pp. 562–563. Newcastle-on-Tyne Electric Supply Co. are constructing new power station to west of existing plant; this will be known as Dunston B, and will have ultimate capacity of six 50,000-kw. sets; initial pressure and temperature will be 600 lb. per sq. in. and 800 deg. steam; after leaving high-pressure turbine at pressure and temperature of 150 lb. per sq. in. and 525 deg., steam will be reheated to 825 deg. before it enters high-pressure cylinder; turbo-alternators will generate three-phase current at pressure of 13,500 volts.

Performance Testing. Governor Performance During System Disturbances, R. C. Buell, R. J. Caughey, E. M. Hunter, and V. M. Marquis. Am. Inst. Elec. Engrs.—Advance Paper, no. 180, for mtg. Nov. 19–22, 1930, 14 pp., 20 figs. Short-circuit tests made at Stanton steam plant during lightning seasons of 1928 and 1929, under normal load conditions in order to ascertain operating characteristics of system and turbine governors during system disturbances; main features of station and connected system; statement of tests, and list of major conclusions.

STEAM PIPE LINES.

High-Pressure. Compensators for Superpressure Steam Pipe Lines (Kompensatoren fuer Hoechstdruckdampfleitungen), W. Paul. Waerme (Berlin), vol. 53, no. 42, Oct. 18, 1930, pp. 796–797, 3 figs. Both smooth and corrugated pipes are discussed; disadvantages of weaknesses in wall in smooth pipe cannot be compensated by wall reinforcements; German patented corrugated pipes are being used more and more for high-pressure lines because of their high elasticity and wall strength.

STEAM POWER PLANTS

Ash Handling. Ash-Handling Diagrams. Power, vol. 72, no. 22, Nov. 25, 1930, pp. 848–849, 1 fig. Where it is possible to, handle both coal and ash with one conveyor, saving can usually be made in first cost of plant; use of one system for handling both materials, however, is not always practicable owing to abrasive character of ash; where ash must be conveyed long distances or where large quantity must be handled daily, systems that convey ash in liquid condition offer certain advantages; typical conveying systems handling both coal and ash are shown in hook-ups.

Coal Handling. Coal Handling and Preparation. Power, vol. 72, no. 22, Nov. 25, 1930, pp. 850–854, 4 figs. Hook-ups shown varying from simplest mono-rail-bucket hoist of small capacity to most extensive system of several hundred tons per hour capacity; two of illustrated systems handle both coal and ash.

Design. Steam Power Generation. Power, vol. 72, no. 22, Nov. 22, 1930, pp. 824–826, 2 figs. Hook-ups illustrate four fundamental ways of heating feedwater; diagrams also show three fundamental surge-tank arrangements.

High-Pressure. High-Pressure Steam Power Plants. Power, vol. 22, no. 22, Nov. 25, 1930, pp. 827–829, 2 figs. Hook-ups for plants in which steam pressure ranges between 500 and 1400 lb. show three methods of reheating steam between high and low pressure turbines.

Superpressure Steam Plants (Hoechstdruck-Dampfmaschine), P. Gilli. Waerme (Berlin), vol. 53, nos. 44/45 and 46, Nov. 8, 1930, pp. 840–844, and Nov. 15, pp. 863–865, 15 figs. Experiences and operating results of Loeffler boiler and superpressure engine; its use in paper mills and chemical plants; Loeffler boiler of Vienna Institute of Technology; future prospects; field of application of superpressure steam; its use in industrial plants; superpressure steam for high-temperature heating.

Use of High Steam Pressure in Power Plants (L'emploi de hautes pressions de vapeur dans les centrales électriques), L. LePaige. Revue Universelle des Mines (Liége), vol. 4, no. 10, Nov. 15, 1930, pp. 303–306, 2 figs. Review of latest developments in high-pressure plants in different parts of world; Schmidt, Benso and Loeffler boilers and their applications.

Oil and Pulverized Coal. Boiler Plant Designed for Multiple Fuel Service. Elec. World, vol. 96, no. 19, Nov. 8, 1930, pp. 860–861, 3 figs. Pulverized coal and fuel oil are economically burned at Somerset station of Montaup Electric Co., near Fall River, Mass.; present installation consists of five 1493-hp. Stirling boilers equipped with superheaters, economizers and air preheaters; steam is generated at 400 lb. per sq. in. pressure, 725 deg. fahr. temperature; original boiler group can be changed from fuel oil to pulverized coal in fortnight with but one unit out of service at time.

Power and Process. Steam Power and Process. Power, vol. 72, no. 22, Nov. 25, 1930, pp. 832–836, 4 figs. Hook-ups shown involve generation of by-product power from steam used later for process and heating; no attempt at consistency in showing reducing valves, feed pumps, condensate and circulating pumps and other essential auxiliaries.

Reheating. Present Status of Reheating Problem (Der heutige Stand der Zwischenueberhitzungsfrage), F. Marguerre. Elektrizitaetswirtschaft (Berlin), vol. 29, no. 520, Nov. 1, 1930, pp. 597–604, 8 figs. Reheating at higher pressures mostly is necessity but also brings considerable thermal gains; flue gas and steam reheating both have advantages and disadvantages dependent upon power plant arrangements; installation cost; behavior in operation; future outlook.

Volcanic. Problem of Utilization of Geothermic Installation in Tuscany (Le problème de l'utilisation des installations géothermiques en Toscane), P. Ginori-Conti. Chimie et Industrie (Paris), Mar. 1930 (special no.), pp. 585–589. Outline of work being carried out at Larderello, Tuscany, for utilization of "soffioni" as source of mechanical power and chemicals.

Waste-Heat-Recovery. Waste-Heat Utilization. Power, vol. 72, no. 22, Nov. 25, 1930, pp. 837–838, 1 fig. Hook-ups 1, 2 and 3, while examples of generation of by-product power from process heat, may be looked upon as recovery for water-heating purposes of waste heat from exhaust of turbines and engines; waste-heat recovery in usual sense is illustrated by hook-up 4.

STEAM TURBINES

Design. Recent Developments in Large Turbine Practice, K. Baumann. Metropolitan Vickers Gaz. (Manchester), vol. 12, no. 211, Oct. 1930, pp. 232–244, 26 figs. Conclusion of